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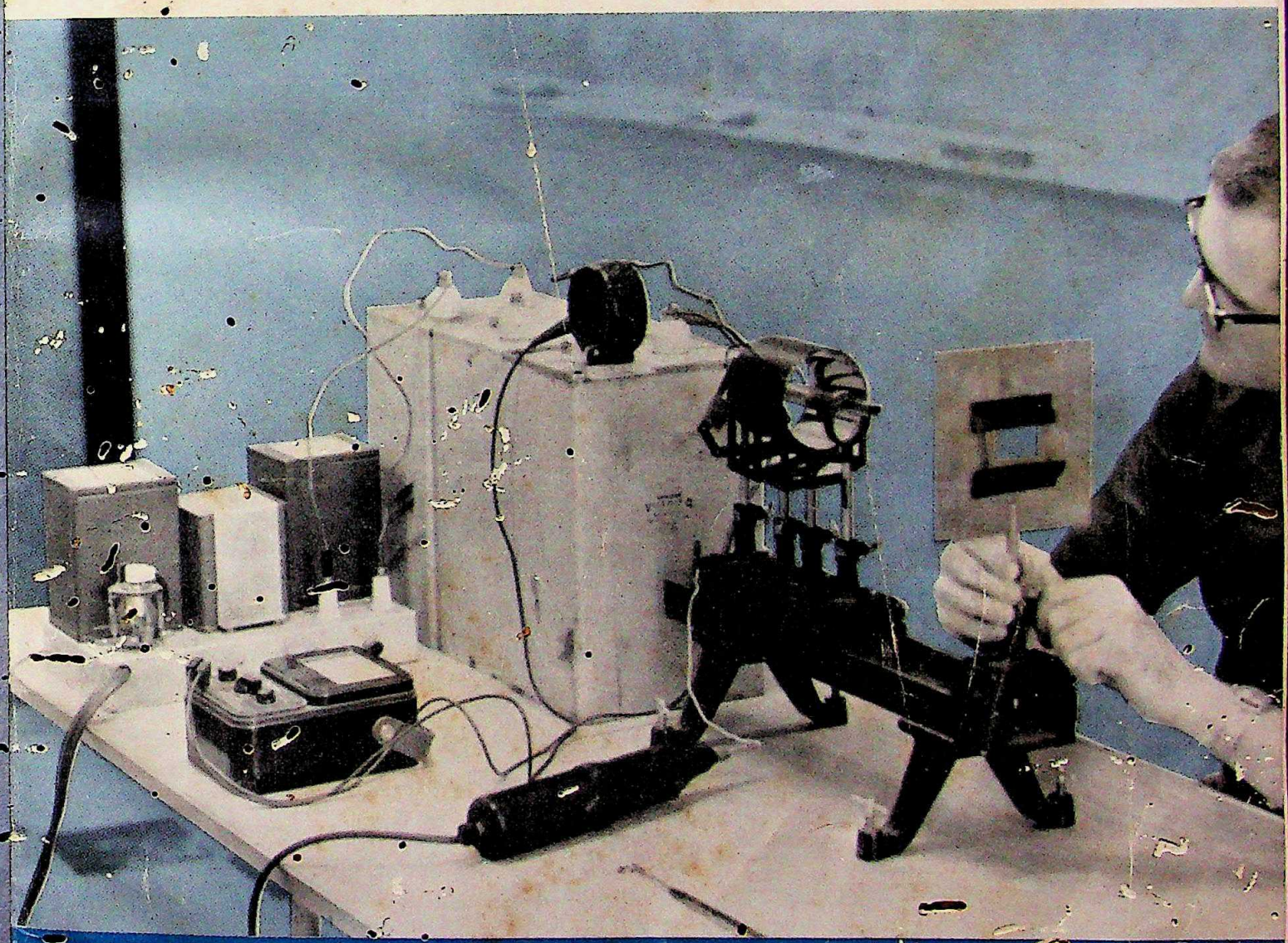

Lasers in the Laboratory . . . page 338

Experiments: Formation Constants . . . 341; Stoichiometry . . . 344

Organics . . . 346-52; Radiochemistry . . . 354

Clock Reactions . . . 366

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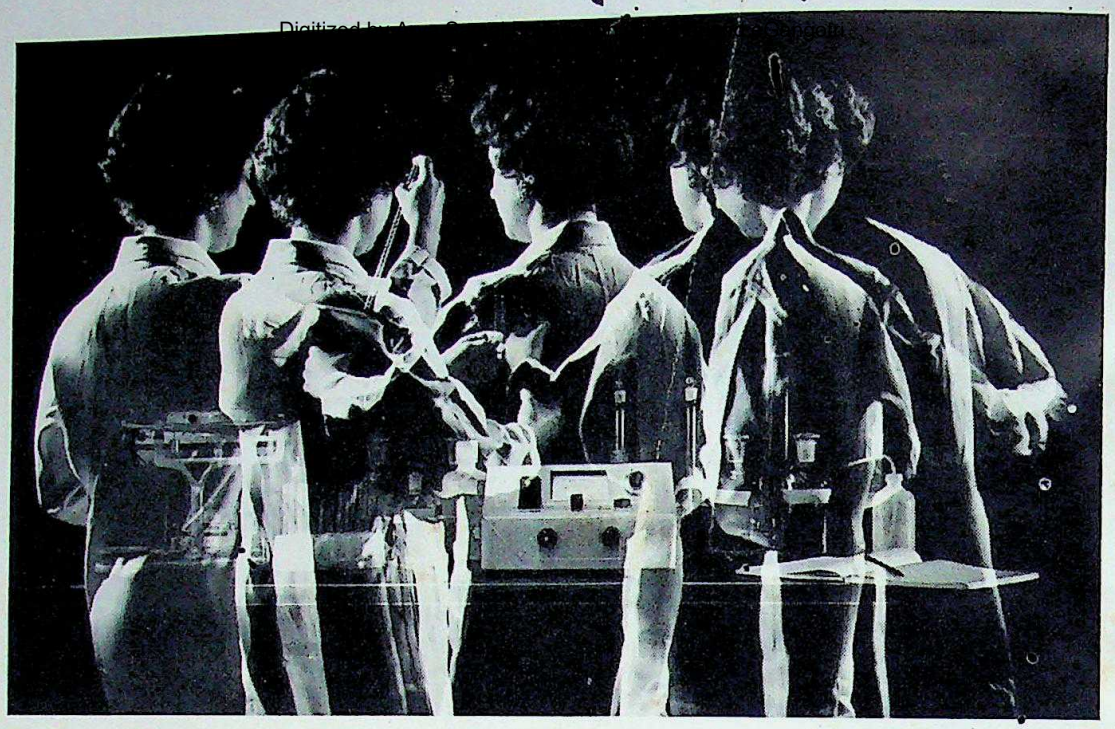

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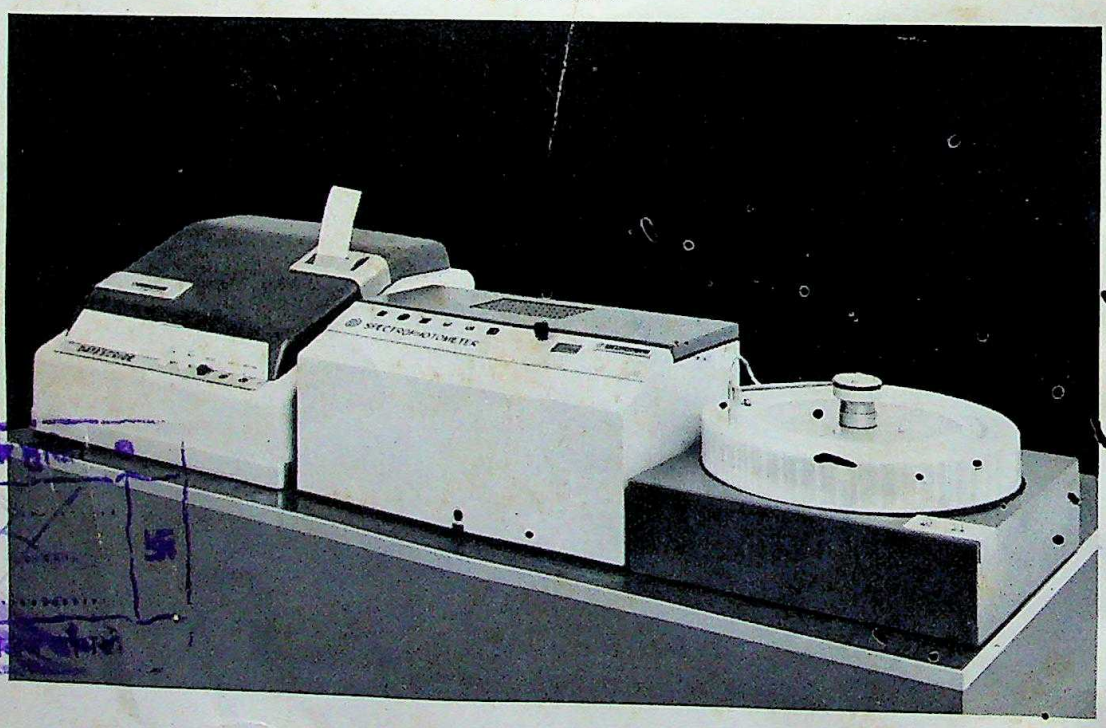

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JOURNAL OF Chemical Education

JULY 1963
Vol. 40 / No. 7

338 Laser Experiments in Undergraduate Physical Chemistry, *Richard G. Layton and Edward M. Eyring*
341 Formation Constants of Metal-Anionic Ligand System in Dioxane–Water, *David E. Goldberg*
344 Some Experiments on the Stoichiometry of Reactions, *H. R. Tietze*
346 Preparation of Diphenylmethane: Simplified Procedure: Purer Product, *William D. Ellis*
347 α-Pinene, a Starting Material for a Sequence of Organic Experiments, *X. A. Domínguez and G. Leal*
349 Esterification for the Introductory Organic Laboratory Course: A Modified Dean-Stark Trap, *W. H. Puterbaugh, C. H. Vanselow, K. Nelson, and E. J. Shrawder*
350 A Simple Closed End Manometer, *Elmer R. Trumbull*
351 Low Temperature Zone Refining Apparatus, *Morris Zief, Hollister Ruch, and H. Schramm*
352 Automatic Apparatus for Zone Refining of Organic Substances, *Eugeniusz T. Knypl and Kasimierz Zielinski*
353 A Simple Approach to the Second Law, *W. G. Breck*
354 Genetically Related Radionuclides: Growth-Decay Studies of ThB-ThC, *P. P. Parekh and M. Sankar Das*
356 Method for Determining Order of a Reaction, *Howard K. Zimmerman*
358 A Qualitative Approach to the Study of Complex NMR Spectra, *Donald E. McGreer and M. M. Mocek*
362 Simple Preparation of Phosphors, *F. F. Mikus*
363 An Experiment with Galvanic Cells for the General Chemistry Laboratory, *Clyde R. Dillard and Patty Hall Kammeyer*
365 An Approximate Wave Mechanical Treatment of the Harmonic Oscillator, *Ronald Rich*
366 Formaldehyde Clock Reaction Theory, *Peter Jones and K. B. Oldham*
367 Flowing Clock Reactions, *M. R. Haggett, Peter Jones, and K. B. Oldham*
369 Placement in General Chemistry, *Virginia M. Schelar, Robert B. Cluff, and Bernice Roth*
370 An Evaluation of the Toledo Chemistry Placement Examination, *Nelson W. Hovey and Albertine Krohn*
373 The Professional Presentation of Scientific Papers, *Harold G. Cassidy*
376 Chemistry at Moscow State University, *Richard E. Bozak*
379 Report of the California Association of Chemistry Teachers: What Is Humic Acid? *Cornelius Steelink*
385 Report of the New England Association of Chemistry Teachers: The Use of n-Center Bonds, *Gene B. Carpenter*

Features

337 Editorially Speaking
388 Letters
389 Book Reviews
A513 Out of the Editor's Basket
A539 Advertisers' Index
A523 TOPS in General Chemistry, *Hubert N. Alyea*
A535 Chem. Ed. Tested Demonstrations, *Frederic B. Dutton*
A491 Topics in Chemical Instrumentation. IX. Micrometric Methods of Volume Measurement. *S. Z. Lewin*
A538 Chemical Projects, *Jay A. Young and John K. Taylor*

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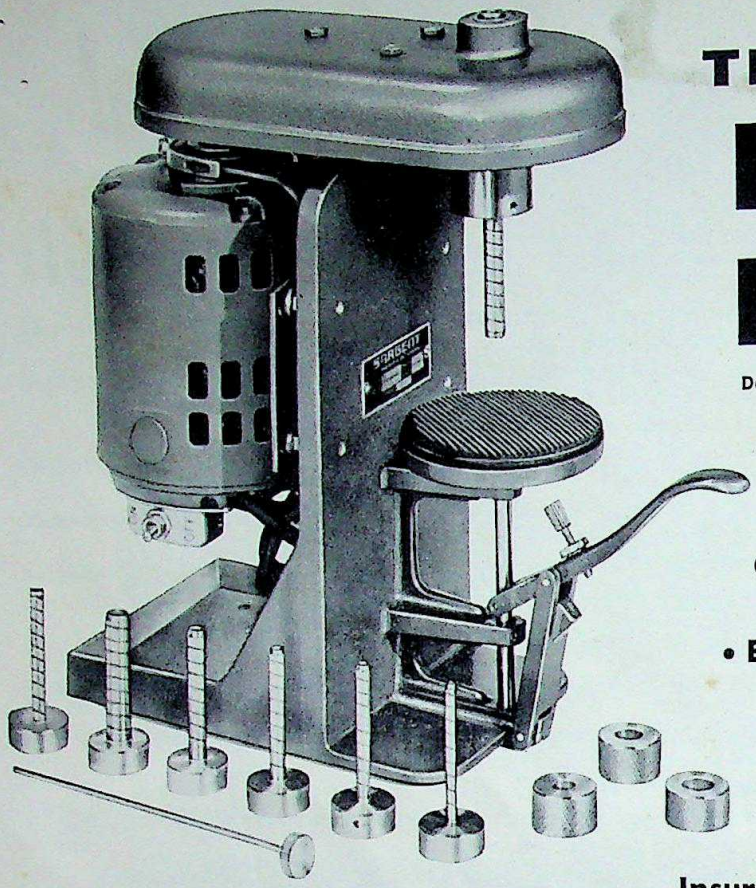

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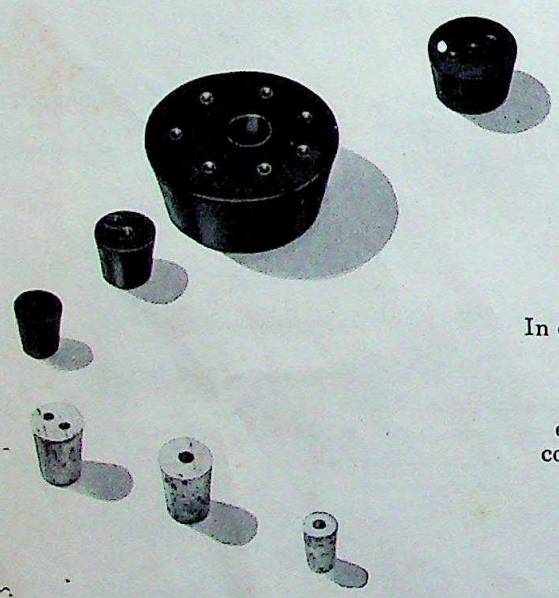

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JOURNAL OF Chemical Education

SEPTEMBER 1963
Vol. 40 / No. 9

446 Tangent-Sphere Models of Molecules. I. Theory and Construction, *Henry A. Bent*

452 An Inexpensive Spectrograph of Moderately High Resolution, *Ralph Schoenbeck* and *Frederick D. Tabbutt*

457 Plastic Dreiding Models, *Louis F. Fieser*

460 A Decade of Unusual Progress, *Edward L. Haenisch*

465 Polymerization Kinetics and Viscometric Characterization of Polystyrene: A Physical Chemistry Experiment, *J. H. Bradbury*

468 Viscometric Depermination of the Isoelectric Point of a Protein, *John E. Benson*

469 A Sobering Experience with Isopropyl Ether Peroxide, *Irwin B. Douglass*

470 Separation of Surface Active Compounds by Foam Fractionation, *R. M. Skomoroski*

472 Freezing Point Observations on Micellar Solutions, *Eric Hutchinson* and *Fumikatsu Tokiwa*

473 Textbook Errors, 45: Catalytic Inhibition by Adsorbed Hydrogen, *S. R. Logan*

475 Demonstrating the Weissenberg Effect with Gelatin, *James H. Wiegand*

476 Preparation and Analysis of a Complex Compound, *Donald K. Sebera*

479 Heterogeneous Equilibria in General Chemistry, *Leonard C. Grotz*

482 Uses for Rubber Eye-dropper Bulbs, *Meyer M. Markowitz* and *Daniel A. Boryta*

483 The Preparation of Inexpensive Lantern Slides, *William H. R. Shaw* and *John N. Aronson*

485 A Simple Condensation Isotherm for a Hard Sphere Gas, *Fred Vaslow*

486 A Unified Kinetic Theory Description of Transport Phenomena, *Eldon Knuth*

489 Proceedings of the California Association of Chemistry Teachers: Conduction and Semiconduction, *Norman J. Juster*

Features

445 Editorially Speaking

497 Book Reviews

A611 Topics in Chemical Instrumentation. XI. Pressure Measurement. Part One, *Seymour T. Zenchelsky*

A635 TOPS in General Chemistry, *Hubert N. Alyea*

A643 Out of the Editor's Basket

A687 Annual Book List

A759 Advertisers' Index

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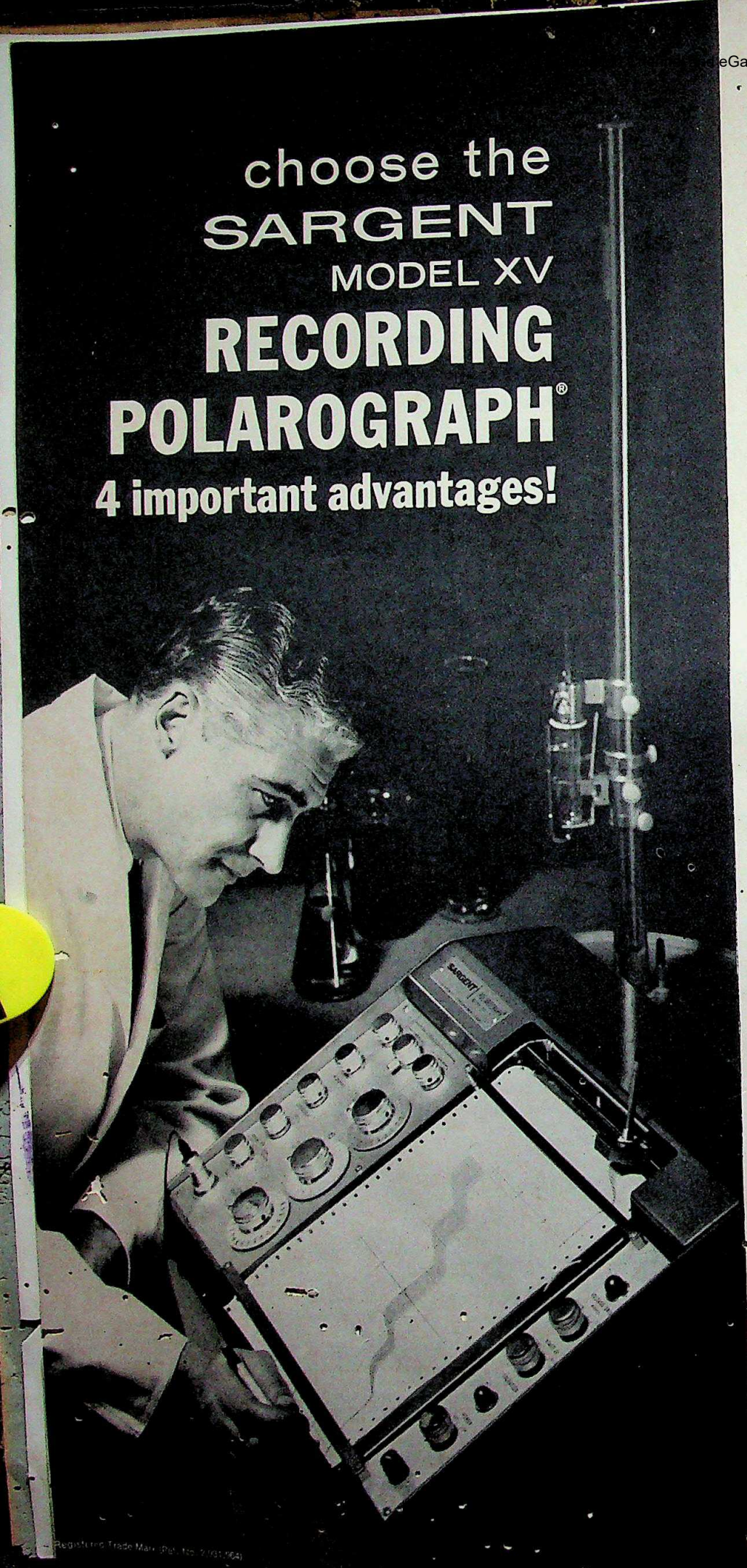

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Vol. 40 / No. 10

504 Cyclobutane Chemistry 1. Structure and Strain Energy, *Armin Wilson* and *David Goldhamer*

512 Crystals, Minerals, and Chemistry, *Duncan McConnell* and *Frank H. Verhoek*

516 Textbook Errors, 46: Deviations from Raoult's Law, *M. L. McGlashan*

519 Potentiometric Titration Curves for Simple Ion Combination Reactions, *James A. Goldman*

523 Tangent-Sphere Models of Molecules. II. Uses in Teaching, *Henry A. Bent*

531 TLC-Versatile Tool, *Donald C. Malins* and *John C. Wekell*

534 TLC on Microscope Slides: An Organic Chemistry Experiment, *M. Benton Naff* and *Anna S. Naff*

536 TLC Separation of Ink Pigments, *Leonard F. Druding*

537 Electrophoretic Study of Synthetic Food Dyes, *M. H. Anwar, S. Norman, B. Anwar,* and *P. Laplaca*

539 A Gas Chromatography Demonstration Apparatus, *John McLean* and *Peter L. Pauson*

541 Determining Activity Coefficients by Gas Chromatography: A Physical Chemistry Experiment, *Susan Kenworthy, James Miller,* and *D. E. Martire*

543 A Diels-Alder Student Preparation, *J. C. Kellett, Jr.*

544 An Improved Synthesis of 2-Bromonaphthalene, *F. A. Vingiello, T. J. Delia, P. Polss,* and *D. Farrier*

545 Simple Method for the Preparation of 2,4-Dinitroaniline, *A. A. Ashton*

546 Laboratory Cylinder-Mill for Small Samples, *M. D. Schlesinger, S. Nazaruk,* and *Leslie Reggel*

547 Proceedings of the California Association of Chemistry Teachers: Organic Semiconductors, *Norman J. Juster*

556 Report of the New England Association of Chemistry Teachers: More Wealth from Agriculture, *William P. Ratchford* and *Norman E. Roberts*

558 An Inverted Mirror Image, *Scott L. Kittsley*

Features

503 Editorially Speaking

555 Letters

559 Book Reviews

A801 Out of the Editor's Basket

A839 Advertisers' Index

A813 TOPS in General Chemistry, *Hubert N. Alyea*

A771 Topics in Chemical Instrumentation. XII. Pressure Measurement, Part Two, *Seymour T. Zenchelsky*

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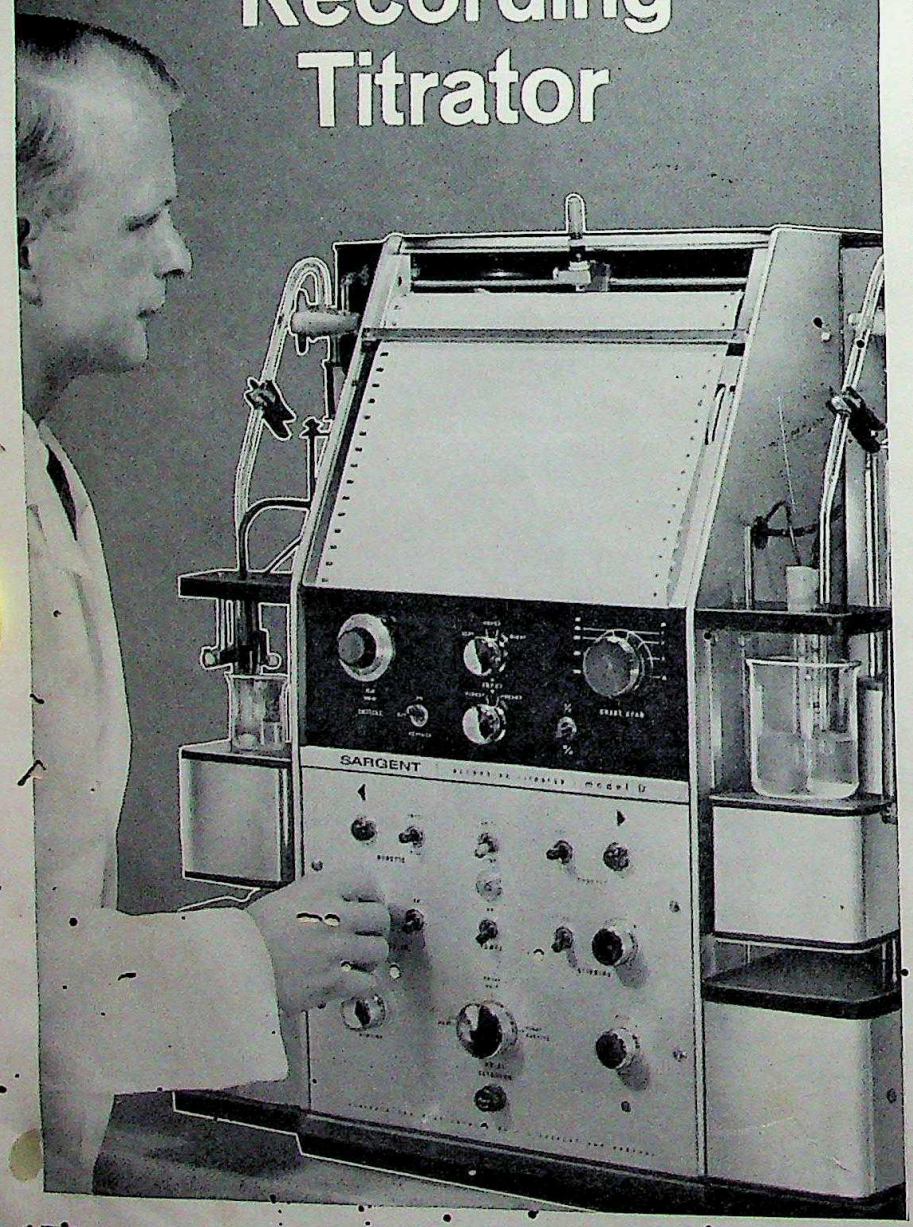

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JOURNAL OF Chemical Education

NOVEMBER 1963
Vol. 40 / No. 11

562 Significant Structure Theory of Liquids, *Henry Eyring* and *R. P. Marchi*

Symposium: Kinetics for the Undergraduate

573 Introduction to the Symposium, *Edward L. King*
574 Concepts of Time in Chemistry, *O. T. Benfey*
578 Kinetics—Early and Often, *J. A. Campbell*
584 A Course in Kinetics Based on Elementary Processes, *Richard M. Noyes*
587 Chemical Kinetics in Laboratory and Classroom, *Robert E. Connick*
589 A Laboratory Program in Chemical Kinetics, *James E. Finholt*

592 Absorption, Dispersion, Circular Dichroism, and Rotary Dispersion, *John G. Foss*
597 A Reaction Vessel for Kinetic Studies below Room Temperature, *G. C. Lalor*
598 Textbook Errors, 47: On Hydrogen Bonds, *Jerry Donohue*
599 Cyclobutane Chemistry 2. Reactions and Mechanisms, *Armin Wilson* and *David Goldhamer*
604 The Current Prominence of Analytical Chemistry, *Sidney Siggia*
605 An Enrichment Program in Chemistry for the Advanced High School Student, *George L. Jones, Jr.*
606 Modified Victor Meyer Apparatus, *G. Wilson Drake*
607 Static and Kinetic Measurements of an Equilibrium Constant: A Physical-Inorganic Chemistry Experiment, *Doyle Britton* and *Z Z. Hugus, Jr.*
611 A Dynamic Method for Measuring Dissociation Pressures, *M. R. Lorenz* and *G. J. Janz*
612 William Allen Miller: Pioneer Stellar Spectroscopist, *Fred Trusell*

Features

561 Editorially Speaking
614 Book Reviews
A873 Out of the Editor's Basket
A917 Advertisers' Index
A885 TOPS in General Chemistry, *Hubert N. Alyea*
A849 Topics in Chemical Instrumentation XII. Pressure Measurement. Part Three, *Seymour T. Zenchelsky*
A888 Chemical Projects, *Jay A. Young* and *John K. Taylor*

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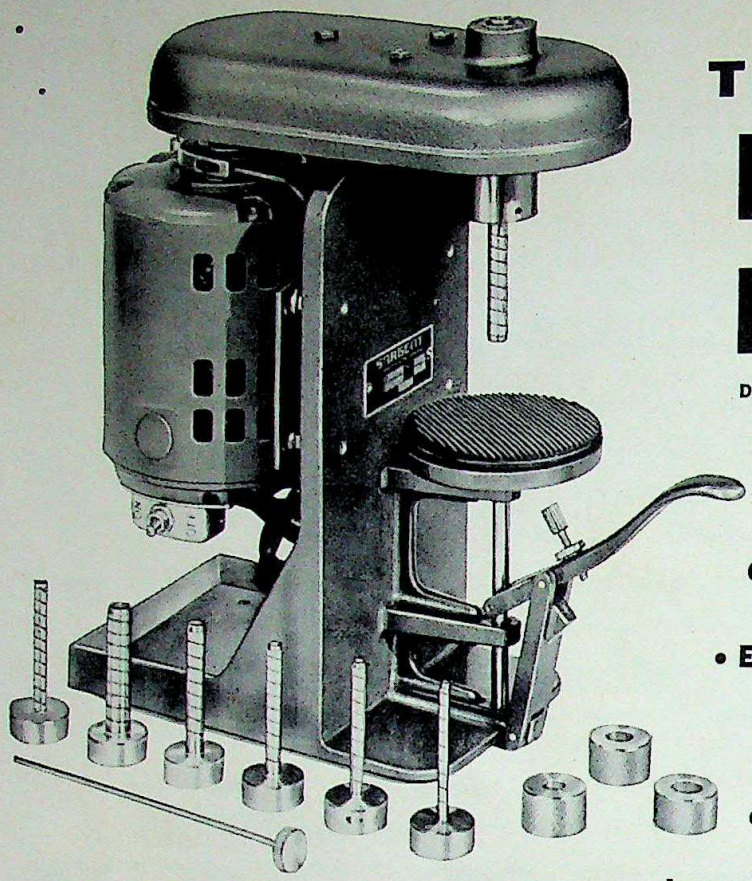

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Vol. 40 / No. 12

618 Criteria for Experiments in Radiochemistry, *Herbert M. Clark*

618 Sponsorship of Committee on Nuclear Science—NAS-NRC, *N. E. Ballou*

626 Dating of Uranium Minerals by the Specific Radioactivity of Lead, *A. W. Fairhall*

633 Alkali Metal-Water Reactions, *Meyer M. Markowitz*

636 Abstracting Publications on Chemical Education in the Soviet Union, *David A. Paterson*

637 The Hydrated Hydronium Ion, *H. Lawrence Clever*

641 Magnetic Stirrer: Instrument for the Freshman Laboratory, *W. H. Slabaugh*

642 National Bureau of Standards Values for Physical Constants

643 Clathrates: Compounds in Cages, *Mary Martinette Hagan, B.V.M.*

646 Benzene Clathrate, *Vijay Mohan Bhatnagar*

648 Duhem and the Gibbs-Duhem Equation, *Donald G. Miller*

649 A Classical Electrostatic View of Chemical Forces, *H. H. Jaffè*

652 Prout's Chemical Bridgewater Treatise, *W. H. Brock*

655 Who Discovered Galvanism?, *Edward F. Kohman*

656 Proceedings of the California Association of Chemistry Teachers: Terpenes to Platinum: The Chemical Career of Lev Aleksandrovich Chugaev, *George B. Kauffman*

665 Division of Chemical Education of the ACS: Report from the Treasurer, *W. G. Kessel*

666 Report of the New England Association of Chemistry Teachers: Official Business, *Robert D. Eddy*

Facing 673 Notice to Authors

673 Annual Index

Features

617 Editorially Speaking, Guest Editor, *Henry Eyring*

667 Letters

668 Book Reviews

A951 Out of the Editor's Basket

A991 Advertisers' Index

A947 TOPS in General Chemistry, *Hubert N. Alyea*

A987 Chem. Ed. Tested Demonstrations, *Frederic B. Dutton*

A927 Topics in Chemical Instrumentation. X. Emission Spectroscopy, *Stephen E. Wiberley and Herbert H. Richtol*

A986 Chemical Projects, *Jay A. Young and John K. Taylor*

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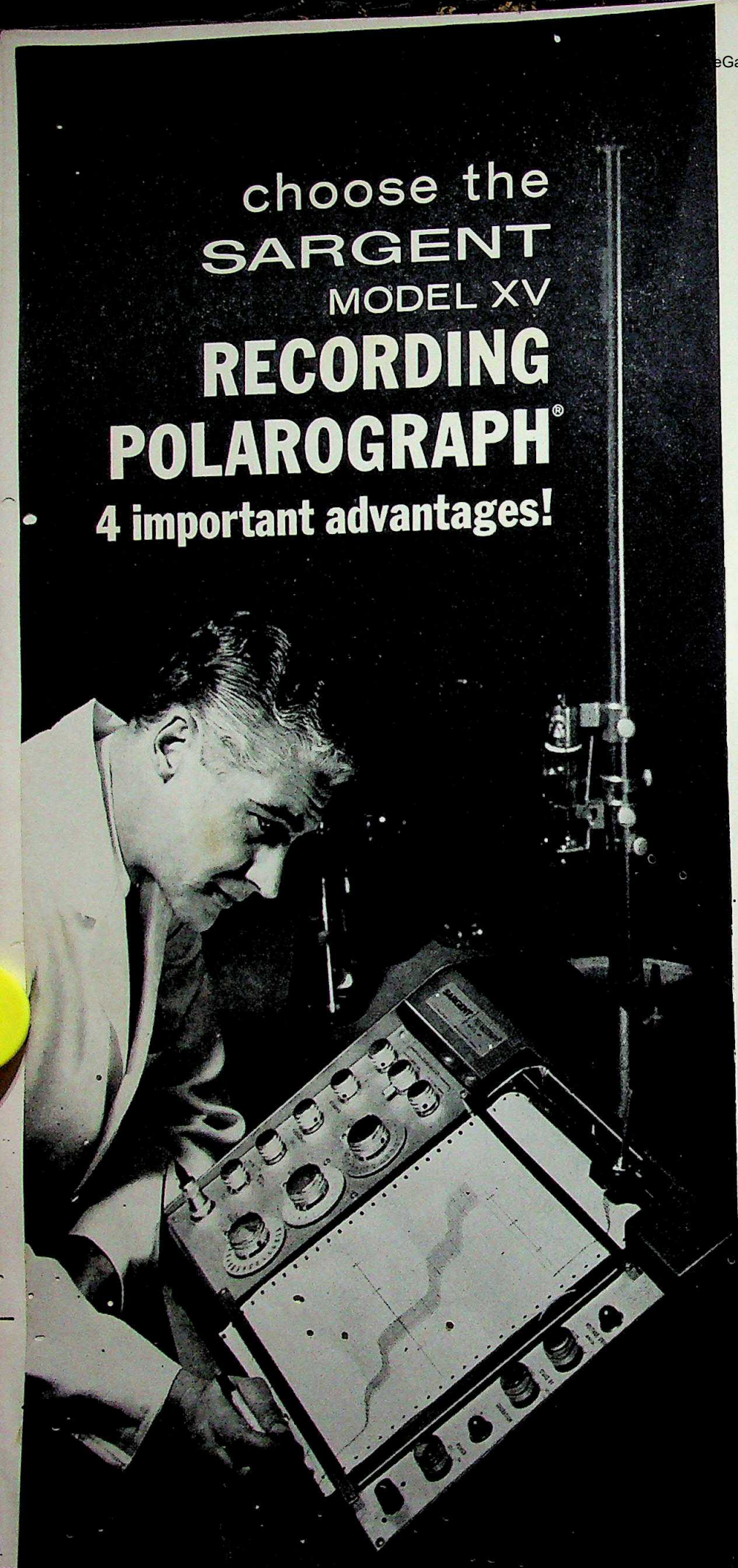

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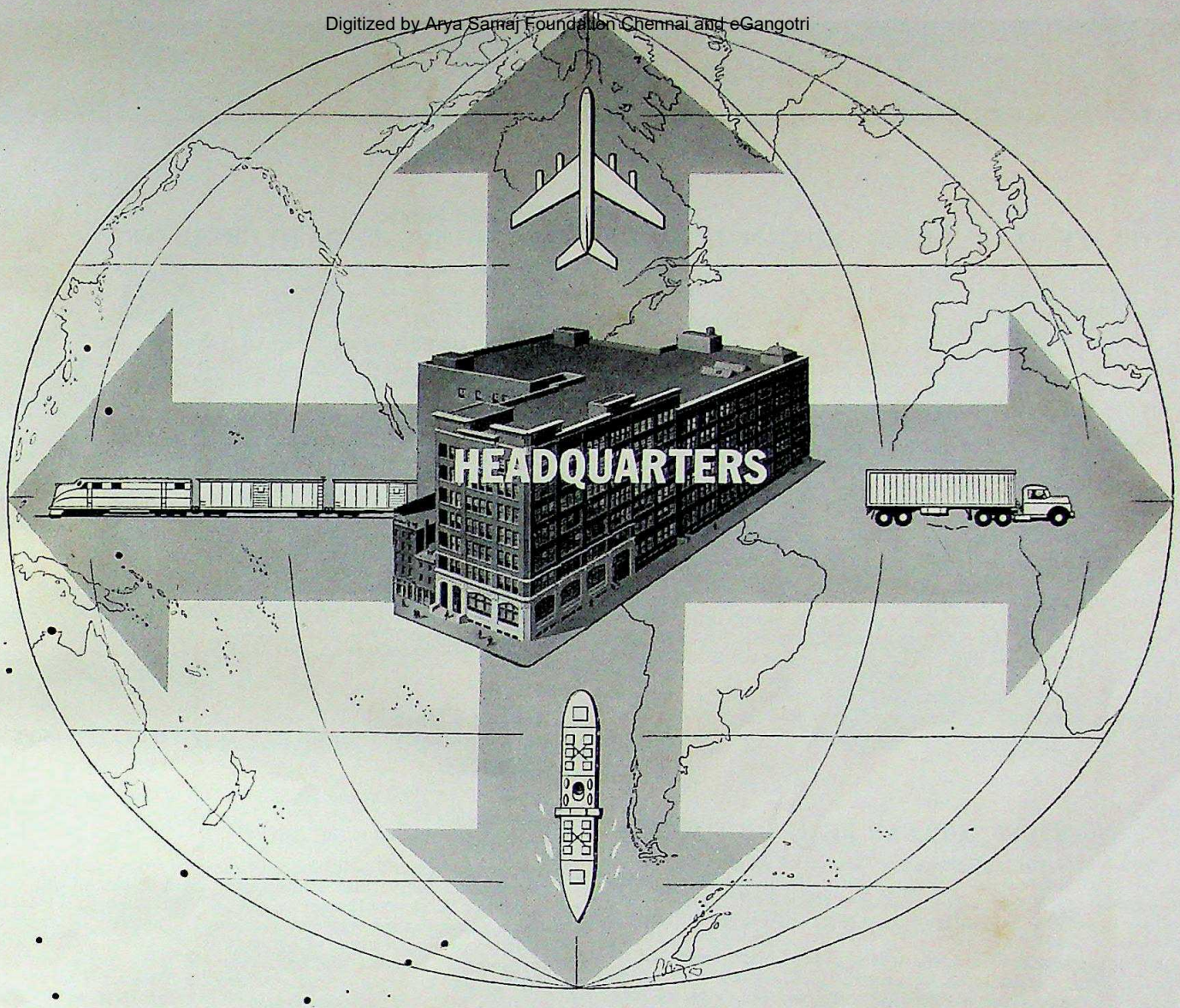

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by Herbert S. Isbin, Department of Chemical Engineering, University of Minnesota at Minneapolis. The Reinhold Chemical Engineering Series/Consulting Editor, Charles R. Wilke, University of California at Berkeley. July 1963. 640 pages. $22.50

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edited by Erich Heftmann, National Institutes of Health, Bethesda, Maryland. Reinhold Chemistry Textbook Series/Consulting Editors: Calvin A. VanderWerf, Hope College, Harry H. Sisler, University of Florida. 1961, 780 pages. $17.50

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IX. Micrometric Methods of Volume Measurement

Roger Gilmont, *Department of Chemical Engineering, Polytechnic Institute of Brooklyn*

Chemical instrumentation has been greatly improved with the introduction of many new devices, including highly sophisticated and complicated apparatus for precise and automatic analysis. Concurrently with the growth of these instruments has occurred the improvement of devices for the measurement of the fundamental quantities of mass, length (as volume) and time. Every chemical analysis must in some way be based upon a fundamental measurement of mass or volume. Normally analysis is an equilibrium measurement independent of time, so that this variable is of lesser importance. In this article we limit the discussion to the measurement of volume and confine ourselves to those instruments which employ micrometric methods of measurement. By micrometric we mean some form of mechanical device that magnifies the sensitivity of measurement of length. This involves the use of the well-known micrometric screw, the equally well-known rack and pinion with gears or a combination of both. The micrometer screw employs the use of a barrel for coarse measurement and a sleeve rotating over the barrel for finer measurement. The rack and pinion is employed in the dial indicating gauge, in which the rotation of the pinion gear is for coarse indication and the rotation of magnification gears is for fine indication. A combination of both methods may be used in the mechanical counter which gives digital readout such that each succeeding wheel gives an additional significant figure in the quantity measured. The above devices have been mentioned in the order of increasing complexity, but with the increasing complexity comes greater ease of reading.

Theoretical Considerations

The measurement of fluid volume in chemical analysis is usually accomplished with a graduated tube of uniform cross section, preferably circular. Equal lengths along the graduated tube will then correspond to equal volumes. The most precise method of calibration involves the weighing of a known liquid contained in or delivered from the space between two given graduation lines. A secondary method of calibration utilizes direct volumetric calculation from the measurement of lengths; thus the volume of a circular cylinder is given by:

$$V = \frac{\pi}{4} D^2 L \qquad (1)$$

where
D = uniform or average diameter
L = length

The accuracy of the measurement in volume will depend upon the accuracy with which both the diameter and length can be measured. We can express this mathematically by differentiating equation (1) to give:

$$\Delta V = \frac{\pi}{2} DL\Delta D + \frac{\pi}{4} D^2 \Delta L \qquad (2)$$

If we divide equation (2) by equation (1) we can express the corresponding deviations on a fractional or percentage basis as follows:

$$\frac{\Delta V}{V} = 2\frac{\Delta D}{D} + \frac{\Delta L}{L} \qquad (3)$$

In equation (3) it is apparent that the fractional or percentage error in volume measurement is obtained by adding twice the corresponding error in diameter to that in length. In the attempt to increase the accuracy of measurement of volume, both factors, namely, diameter and length, must be increased com-

(*Continued on page A492*)

Roger Gilmont, Adjunct Professor of Chemical Engineering at the Polytechnic Institute of Brooklyn is also President of his own company, Roger Gilmont Instruments, Inc. He obtained his B.Ch.E. (1939) from the Cooper Union Night School of Engineering and his M.Ch.E. (1943) and D.Ch.E. (1947) from the Polytechnic Institute of Brooklyn. During his graduate study at night he worked for the Federal Civil Service successively as a draftsman for the Coast and Geodetic Survey (1940), a chemical engineer for the Quartermaster Corps (1941), and a physical chemist for the National Bureau of Standards (1942–43). His professional career continued with teaching chemical engineering at the College of the City of New York (1943–44), being in charge of the physical measurements laboratory at the Central Laboratories of the General Foods Corp. (1944–47), acting as technical Director of the Emil Greiner Co. and vice-president and president of the Manostat Corp. (1947–61), and finally starting his own company in 1961. During this time he has been teaching at the Polytechnic Institute of Brooklyn in the graduate and undergraduate night schools (since 1947) giving courses in electrochemical technology and thermodynamics. He has recently completed a textbook on Chemical Engineering Thermodynamics (Prentice-Hall 1959). His interest in chemical instrumentation started in 1942 while working at the National Bureau of Standards. Since then he has written many papers on instruments covering a wide field of measurement and has been granted several patents including some concerned with micrometric volume measurement.

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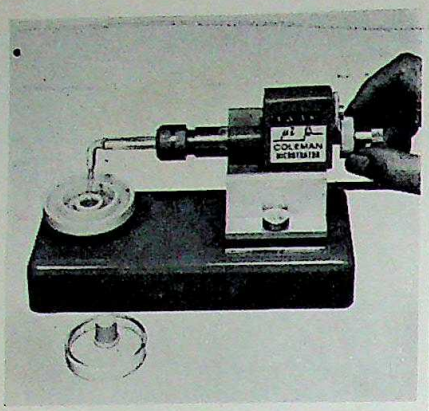

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parably, since a gain in accuracy of only one of these factors would be essentially negated by the error in the other factor.

Since the simple buret or graduated pipet is calibrated primarily against a weight measurement, the question of accuracy in length or diameter is normally not encountered. The variations in diameter of standard glass tubing used in the manufacture of burets or pipets are sufficiently minor so that linear calibration can be obtained with no more than five check points per tube. Recent use of precision bore glass tubing (made by shrinkage of the glass over high precision metal mandrels under vacuum) eliminates the need of any check points or at worst a single check point is occasionally needed. As the volume is reduced, the bore of the tube is proportionately reduced by the square root of the volume and eventually a point is reached where capillarity and drainage errors become intolerable. This is where micrometric methods become imperative. However, this does not preclude the use of micrometric methods for the measurement of comparatively large volumes. The state of the art has been developed at present where several practical commercial instruments are available employing micrometric methods for the measurement of macro-volumes.

Micrometric Devices

The three basic methods of micrometric measurement are shown schematically in Figure 1. Part *a* of this figure is the micrometer screw type. The screw is selected with a convenient number of threads so that each turn corresponds to an even measurement of length. In the English system this corresponds to 0.025 in. while in the metric system it is 0.5 mm. These values are for the standard instruments and in either case involve a slight complexity in reading especially for the English system where each 0.1 in. corresponds to four complete turns. When the micrometer is "tailor-made" for the particular application, each turn is made to correspond to 10 or 100 units of the quantity being measured, thus greatly improving the ease of reading. In this way one turn of the sleeve reads in multiples of ten and the complete reading can be made without additions or subtractions that may lead to gross errors. Unfortunately, many instruments employing micrometer screw devices use the standard types, mainly for economic reasons. For the average chemist who is normally not familiar with the reading of standard micrometers, this minor difficulty may become a source of irritation because of the constant danger of misreading.

The dial indicating type shown in part *b* of Figure 1 is an improvement over the micrometer screw as far as ease of reading goes; however, this is accomplished at the expense of simplicity

(*Continued on page A494*)

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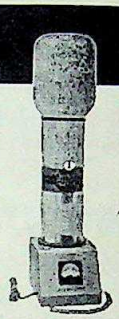

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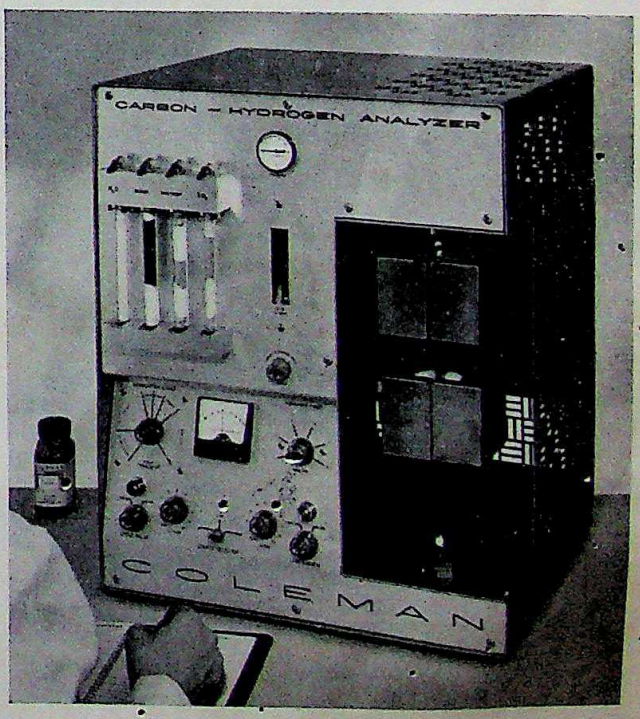

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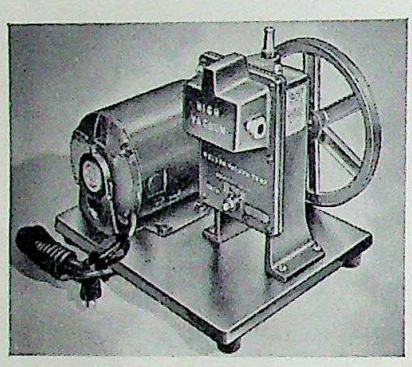

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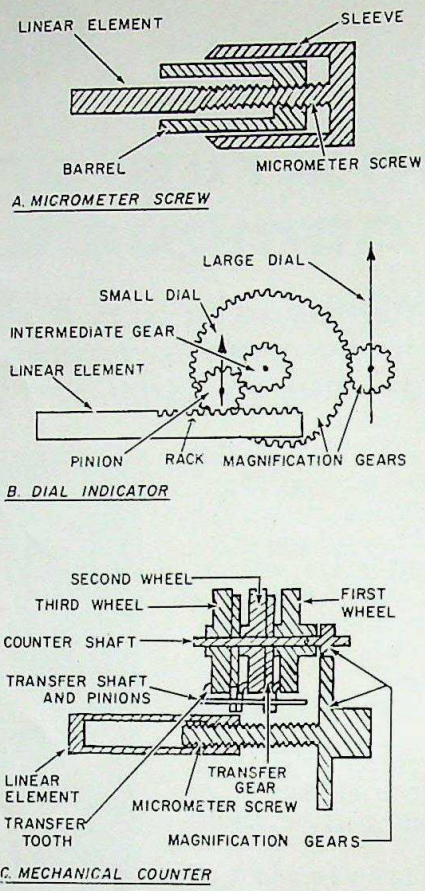

Figure 1. Three basic types of micrometric devices.

and, where high precision is involved, at some expense of accuracy. The rack drives a pinion gear which reads the number of complete turns of the large dial. By selecting the proper pitch of the rack and the number of teeth in the pinion gear, these instruments are easily made to read in multiples of 10 for either the English or metric systems of measurement. Each complete turn is usually divided into 100 units on the large dial which is driven by a set of gears that magnify the rotation of the pinion by a factor of ten. In this way, the dial becomes a direct decimal reading instrument which is very convenient to use and practically free of gross errors.

The mechanical counter in part *c* of Figure 1 combines the accuracy of the micrometer screw with the simplest type of readout, namely, individual digits for each significant place. This, of course, is done at the expense of simplicity and, because of the added cost, is reserved for the more expensive instruments. A micrometer screw is used to drive the linear element of the device, and through a system of gearing this motion is translated into a digital readout. Proper selection of the pitch of the screw and number of teeth in the gears correlates the rotation, so that one complete turn of the first wheel of the counter (counting from the left) corresponds to a multiple of 10 units of the quantity being meas-

(*Continued on page A496*)

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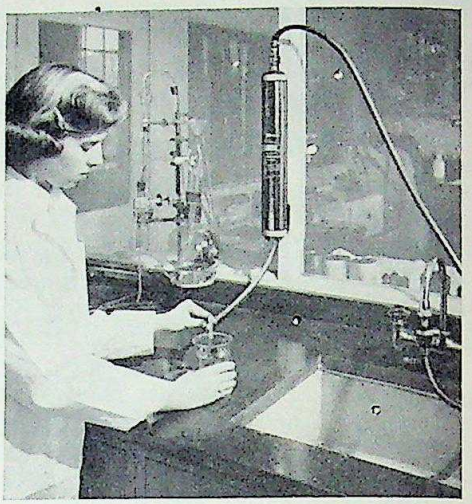

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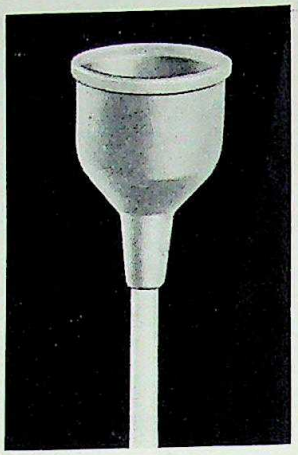

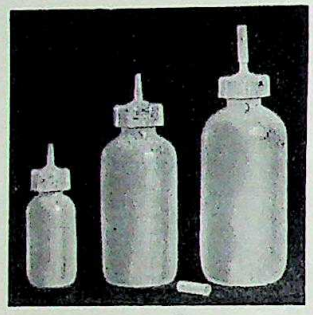

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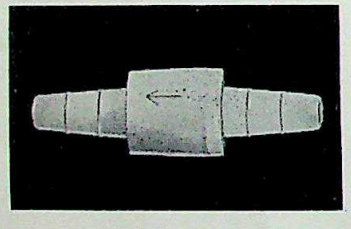

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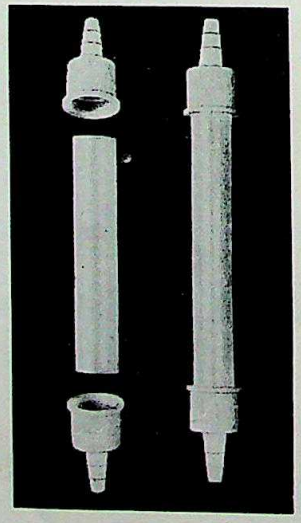

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ured. This motion may be magnified up to the mechanical strength of the rotating parts. Using high speed counters magnifications as high as 100 and even 1000 may be used depending upon the speed of rotation of the micrometer screw. When the first wheel completes one turn, through a simple transfer mechanism the second wheel is made to rotate $^1/_{10}$ of a complete turn corresponding to a change of one digit. Thus, after ten turns of the first wheel, the second wheel has made a complete turn and transfers its motion to the third wheel in the same manner as before. This procedure may be continued until the desired number of wheels is used. In some applications as many as ten wheels have been used. The usual number found in these devices varies from three to five wheels.

The first wheel may be graduated between the digits allowing for additional interpolation. With 50 divisions around the circumference of the first wheel, an additional significant figure can be estimated in the final reading.

Mechanisms are available for resetting the counter to zero. The most commonly used involves springs and ratchets with an additional knob on the counter shaft so that the wheels may be reset by rotating in the opposite direction.

Fluid Reservoirs

Each of the three micrometric devices may be combined with one of three types of fluid reservoirs shown in Figure 2.

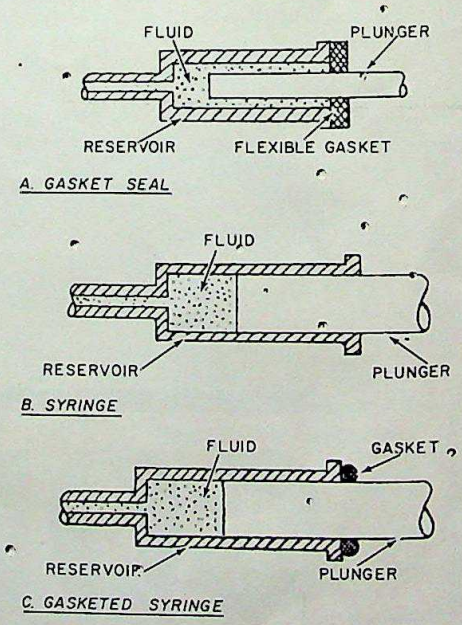

Figure 2. Three types of fluid reservoirs.

In part *a* of this figure is illustrated the gasketed plunger, in which the clearance between the reservoir and plunger is made fluid tight by means of a flexible gasket. The second type shown in part *b* is the familiar syringe in which the clearance between reservoir and plunger is made so small that a virtually fluid tight

(*Continued on page A498*)

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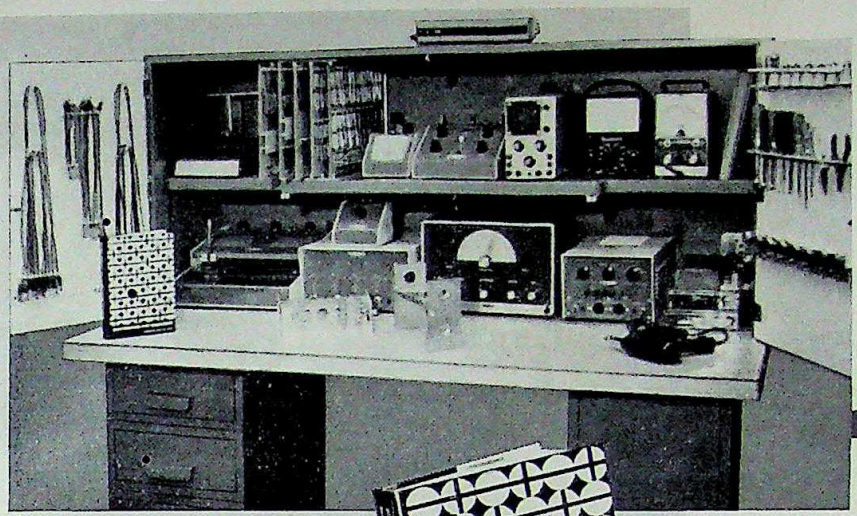

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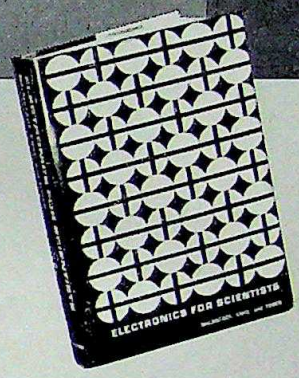

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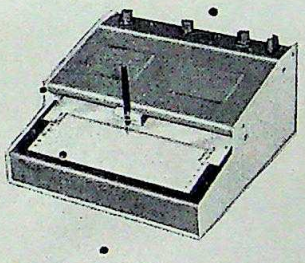

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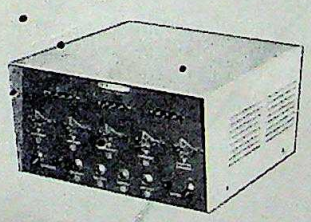

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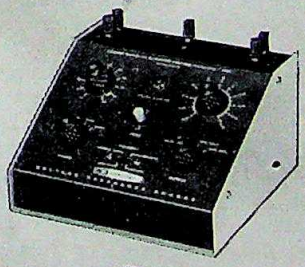

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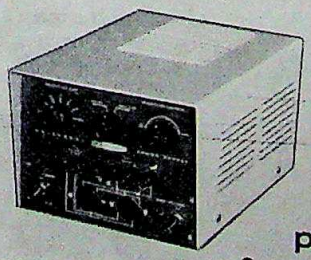

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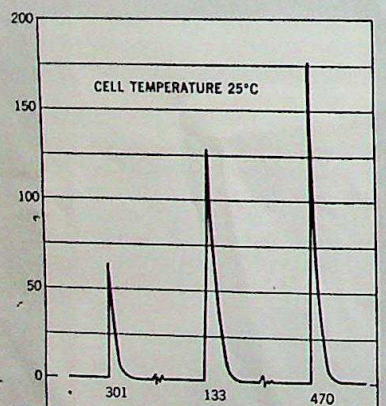

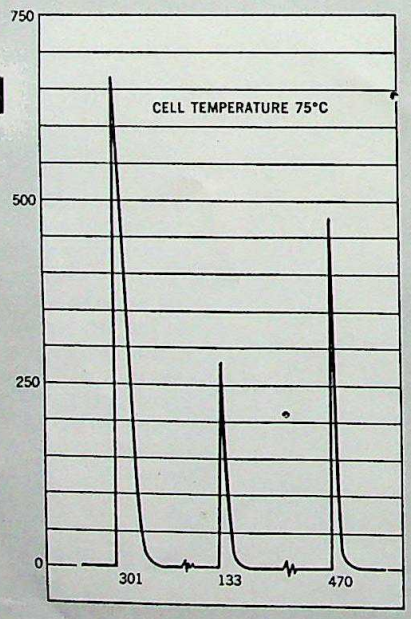

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seal is effected. An extremely thin film of grease may be used to improve this seal. Recently, a thin coating of Teflon has been used on the plunger to improve the tightness of this seal without the need of grease. The third type shown in part *c* is a combination of the syringe and gasket types in which the flexible gasket insures a high vacuum seal. The "O" ring type gasket has been found most effective for this seal.

In the larger sizes, plungers have been made of glass, Vycor, and ceramics. In the smaller sizes stainless steel is most popular; although in very fine bores platinum-iridium alloys have been economically employed. When ultrahigh accuracy is not required, inert plastics such as Kel-F and Teflon have been used.

The reservoir is normally made of glass and in the syringe types precision bore tubing is most popular, especially for the smaller bores. The precision bore tubing eliminates the difficult operation of internal grinding and makes the parts interchangeable. The most popular material employed in the gaskets are synthetic rubbers (and elastomers) including neoprene, silicone, and Viton.

Historical Background

Practically all possible combinations among the micrometer devices and reservoirs have been used in the past. The first application was made by Emich (*1*) combining a homemade micrometer screw with a gasketed reservoir having a sensitivity of 4×10^{-6} ml. This was later improved by Dusing (*2*) and Scholander (*3*) using standard micrometer screw devices. An instrument of this type capable of a sensitivity of 7×10^{-8} has been described by Scholander and Evans (*4*).

The syringe in combination with a micrometer screw device was first described by Trevan (*5*) and later improved by Dean and Fetcher (*6*). These devices eliminated the use of mercury as an intermediary fluid but only at a sacrifice in accuracy. The accuracy of the syringe type was made comparable to the reservoir type by Hadfield (*7*) who employed precision bore glass tubing and a precision ground steel rod.

The dial indicating type of instrument with the gasketed reservoir was first introduced by Gilmont (*8*) who later modified this instrument to yield a sensitivity of 1×10^{-9} ml (*9*). It was later adapted for use with a syringe by Lazarow (*10*).

The mechanical counter for this application was disclosed by Lingane (*11*) who employed it in a motor driven titrating apparatus with syringe reservoir.

Presently Available Instruments

Most of the types of instruments discussed in the historical background are commercially available. These will be

(*Continued on page A500*)

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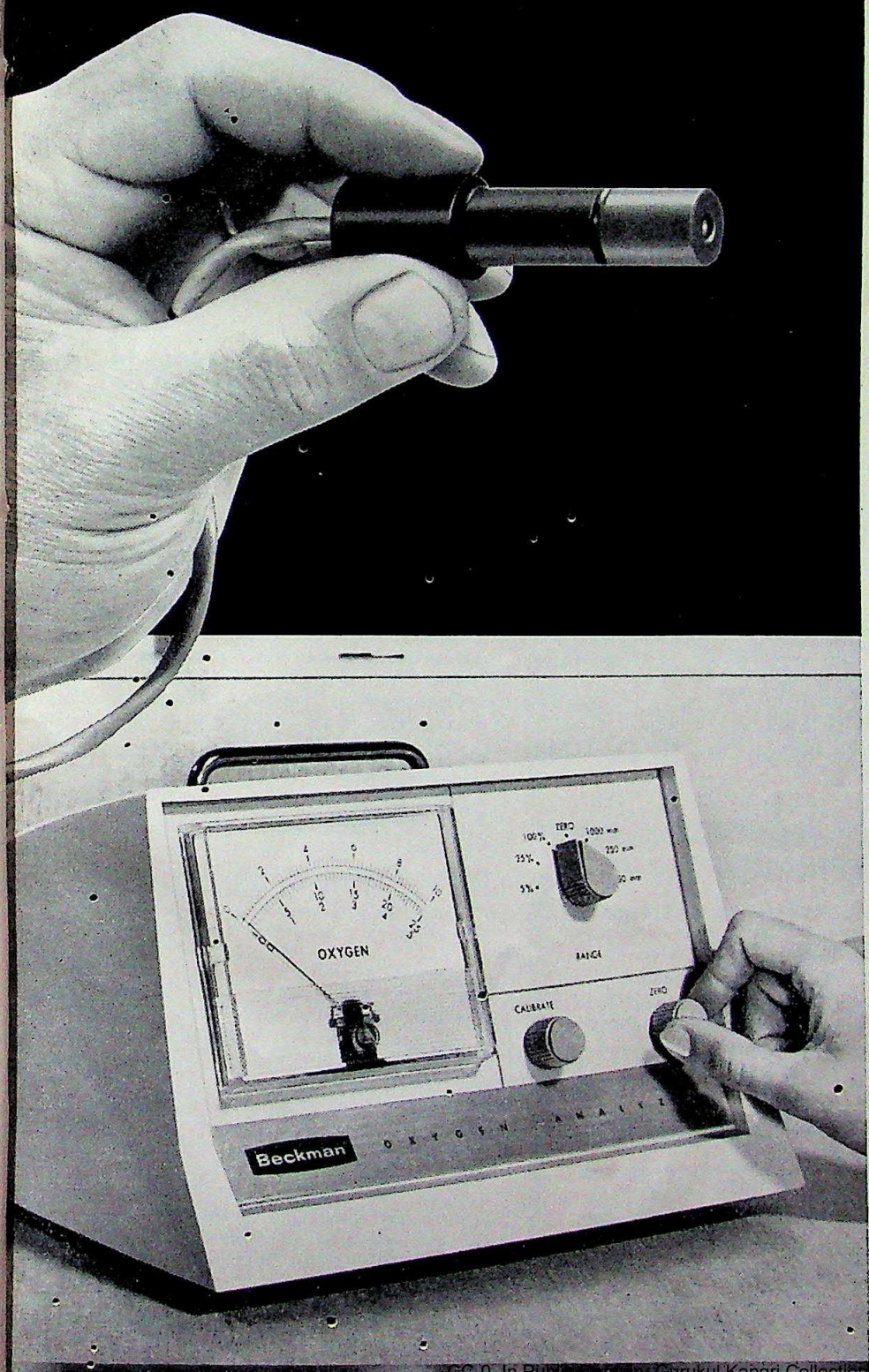
new Beckman system

measures gaseous O_2 and dissolved oxygen



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Beckman Oxygen Adapter allows the Beckman Model 76 Expanded Scale pH Meter to function as an oxygen analyzer. The Model 76 can then provide the same oxygen measurement ranges as the Model 777 with the same accuracy. The laboratory is thus equipped with a multi-purpose instrument readily convertible for either pH or oxygen measurements.

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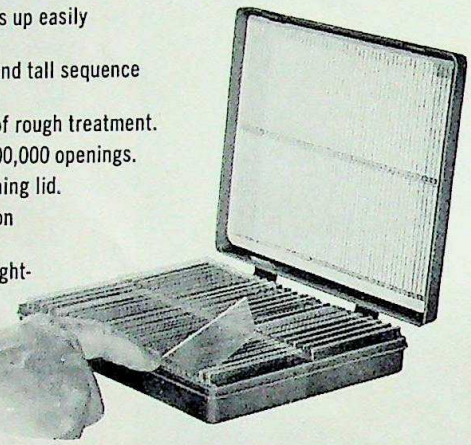

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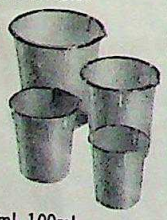

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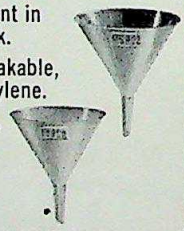

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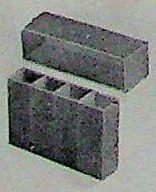

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described according to the classification of the kind of micrometric device employed. In addition a group of microgasometers related to these instruments also will be described.

Micrometer Screw Types

An example of the gasketed reservoir and micrometer screw is shown in Figure 3.

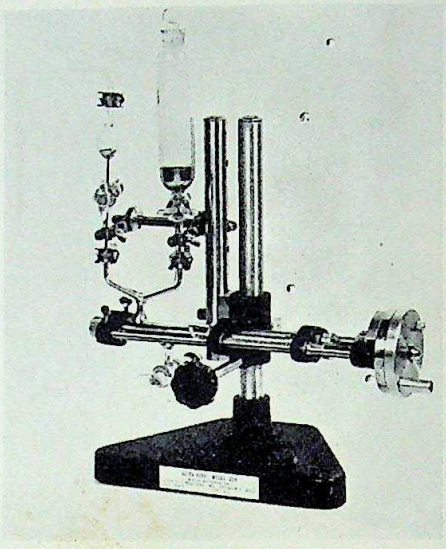

Figure 3. (Courtesy of Scientific Industries, Inc., 220-05 97th Ave., Queens Village 29, L.I., N.Y.) A combination of a tailor-made micrometer and gasketed reservoir has high range and accuracy.

This instrument features a tailor-made micrometer device with a large handwheel containing 100 divisions of 0.001 ml capacity each. The total capacity is 7 ml and a reservoir of 50 ml is included to contain additional solution. The instrument employs mercury as the secondary fluid which is typical of the gasketed type. The complete assembly is mounted on a base making it very convenient for titrations. The basic instrument and a number of useful accessories are available.

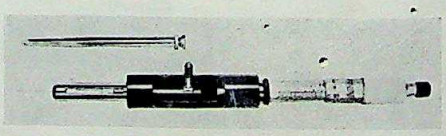

Figure 4. (Courtesy of California Laboratory Equip. Co., 1717 Fifth St., Berkeley 10, Calif.) A combination of a standard micrometer head and syringe in a simple convenient arrangement.

A compact combination of a standard micrometer head and syringe is given in Figure 4. The plunger of the syringe is a tight fitting Teflon piston so that the fluid contacts only glass, Teflon, and the stainless steel needle. The glass is precision bore to assure a fluid tight seal with the piston. A standard metric micrometer is used having divisions of 0.0001 ml each with a total capacity of 0.25 ml. The design of the instrument is most convenient for dispensing repetitive samples of equal volume. A microburet attachment is supplied with each instrument.

(Continued on page A501)

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In Figure 5 is illustrated an adaptation of the micrometer screw syringe that delivers ultra micro quantities of fluid from 10 to 300 μl at constant rate after releasing with a trigger device. It is spring-operated.

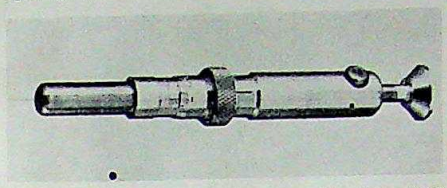


Figure 5. (Courtesy of Hamilton Co., Inc., 540 W. Lambert Rd., Whittier, Calif.) A micrometer screw combination with a fine bore syringe, spring driven to deliver micro quantities at constant rate.

Figure 6 is an illustration of the micrometer screw in combination with a gasketed syringe. The micrometer head is made completely of corrosion-resisting plastic and is direct reading with fifty divisions per turn and twenty complete turns. The reservoir is precision bore Pyrex* tubing into which a precision ground Teflon plunger fits. A Viton "O" ring gasket makes the assembly vacuum-tight as well as fluid-tight. Simple construction makes this instrument relatively inexpensive. Two capacities of 0.2 and 2.0 ml are available in either the syringe or buret types.

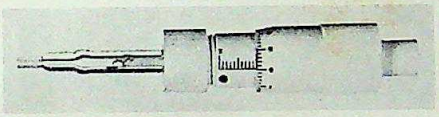


Figure 6. (Courtesy of Roger Gilmont Instruments, Inc., 44-27, Douglaston Parkway, Douglaston 63, N. Y.) An all plastic micrometer screw device combined with a precision bore gasketed syringe. Highly corrosion resistant and extremely simple in design.

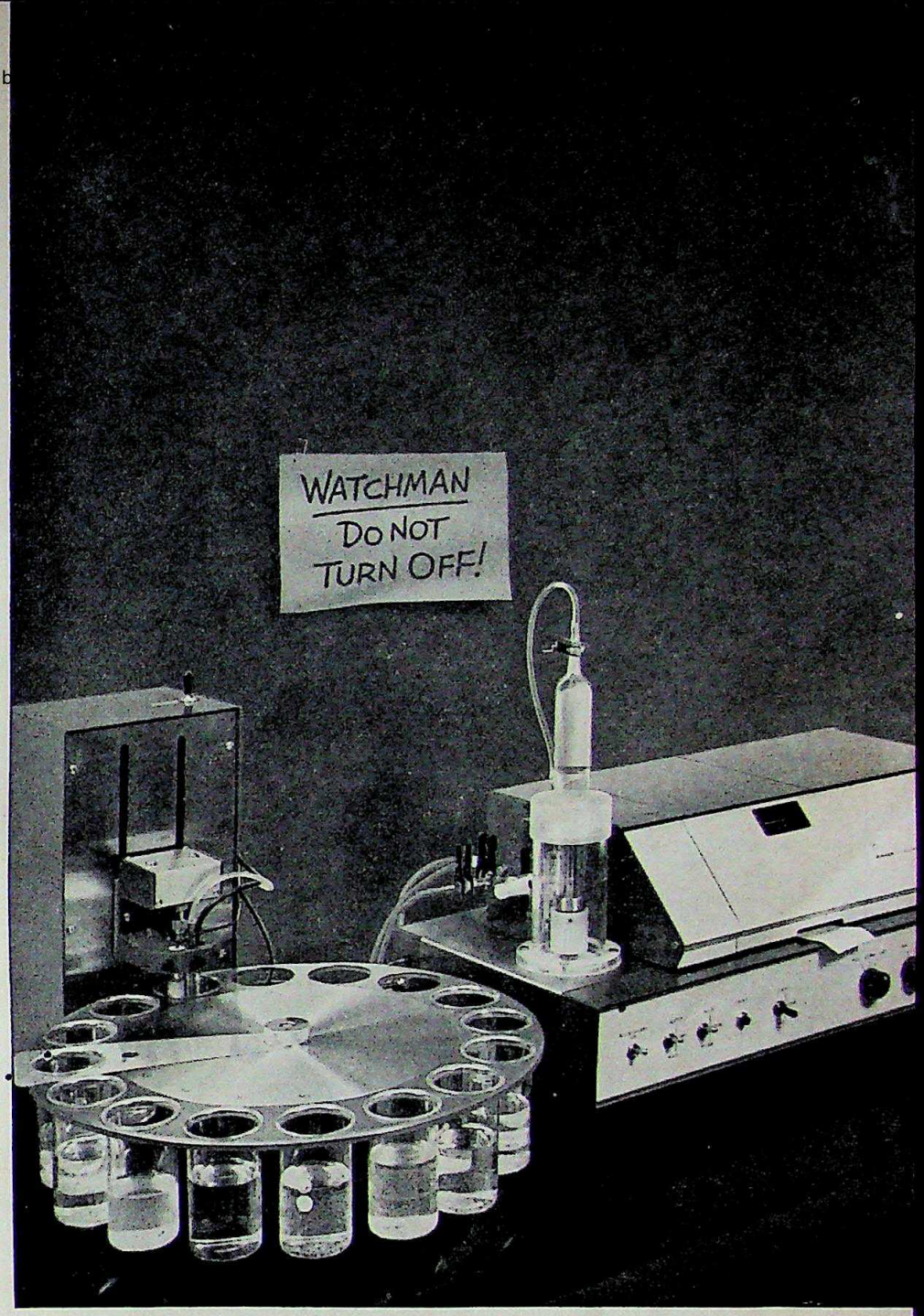
A motorized modification of the micrometer screw syringe is given in Figure 7. The syringe is operated as a piston buret with precision bore glass and a Teflon piston. A large wheel contains 100 divisions and the number of turns shown on a linear scale is 10. Two capacities are available; namely, 10 ml in 0.01 ml divisions and 20 ml in 0.02 ml divisions. Less expensive models are available in hand driven types; these are filled with a lever action and fluid is dispensed by rotating the wheel.

Dial Indicating Types

A combination of the dial indicator and gasketed syringe is shown in Figure 8. The use of a Kel-F plunger eliminates the need of mercury as a secondary fluid. It has a total capacity of 200 μl with each division of the dial equal to 0.005 μl. There is also a zero reset mechanism and a built-in vibrating stirrer. The complete assembly is compactly mounted on a single base making it very easy to perform ultra-micro titrations.

The dial indicator in combination with a syringe is illustrated in Figure 9. Standard syringes may be selected so that each

(*Continued on page A502*)



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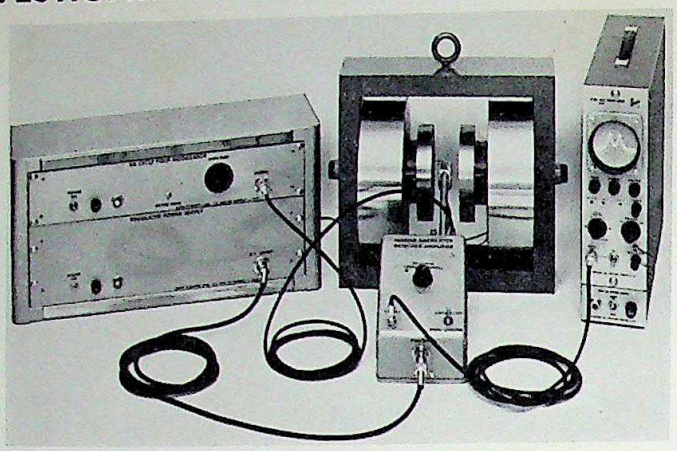

ALPHA'S ESR spectrometer is available at extremely moderate cost, can be purchased piecemeal, and provides insight into chemical fine and hyperfine structure immediately upon receipt. The basic units are available for only $1190.00 (if you already have a magnet) and the modulator, phase detector and recorder can be added if research requirements call for graphic presentation.

This precision system was developed to meet the need for an electron spin resonance device which is simple to operate and yet has the sensitivity and high resolution to provide a complete insight into chemical fine and hyperfine structure.

To operate, it is only necessary to turn on the main switch and drop the sample tube into the resonant structure. Adjustments for changing the ESR signal characteristics or amplitude may be carried out on a repeat run of the sample if desired. Once the system has been set up to observe a signal on one sample, samples of other materials may be run with little or no change in dial settings. Rapid determination of the ESR spectra of a large number of samples in the course of a few hours is readily accomplished.

Operation is set in the neighborhood of 340 Megacycles, but may be varied between 320 and 350 Megacycles. This operating frequency was chosen because it permits the study of samples containing water, metals, and many other substances which are too lossy at higher (microwave) frequencies to provide for sensitive detection. Considering the fact that a larger sample may be used with the AL340 at 340 megacycles compared to higher frequencies, the sensitivity using large samples compares favorably with the sensitivity of higher frequency spectrometers. Thus, for maximum sensitivity per microgram of sample the higher frequencies are often superior, and for maximum sensitivity per total sample volume, the AL340SY will often prove to be the ideal instrument.

ELECTRON SPIN RESONANCE: Electron spin resonance (ESR) involves the detection of radio frequency energy absorption by unpaired electrons in a magnetic field.

Typical substances which are suitable for study by means of ESR equipment are:
1. Free radical in crystals or solutions.
2. Crystals composed of transition elements.
3. Free radicals in living tissue.
4. Crystals containing free electron spins such as F centers in the alkali halide crystals.
5. Crystals with broken bonds and a consequent electronic magnetic moment, such as neutron or x-ray damaged materials (lattice defects).
6. Semiconductors with donor or acceptor impurities.
7. Metals and semiconductors exhibiting cyclotron resonance.
8. Ferromagnetic materials.
9. Ferrimagnetic materials.
10. Many organic materials with complex bonding.
11. Coals and chars.
12. Biradicals.
13. Materials in triplet electronic states.
14. Glasses.
15. Most natural minerals.

These categories of materials may be investigated using ESR to obtain information regarding molecular and crystal structure, chemical reactivity, analysis of the substance degree and type of impurities, radiation damage effects, and catalytic and enzyme reactions. ESR also has applications to research in chemical kinetics, photosynthesis, and carcinogenic studies.

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Output Power: Variable-Maximum, 200 milliwatts.
High Sensitivity: Sensitivity of approximately 10^{14} spins per gauss line width. The large sample capacity permits ESR spectra observations in materials with low electron spin densities. Detection of a billionth of a gram of dispersed alkali metals in solution has been recorded.

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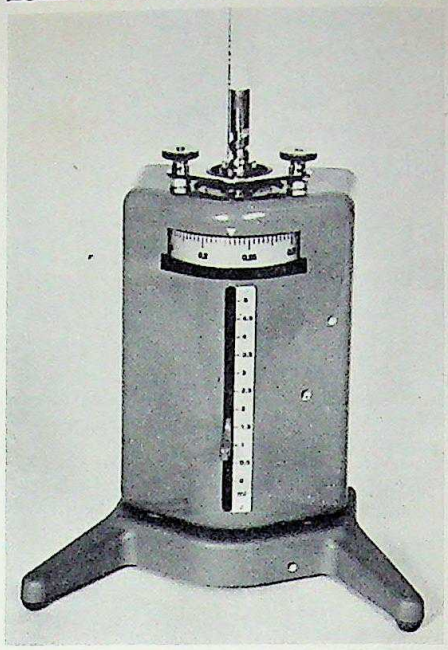

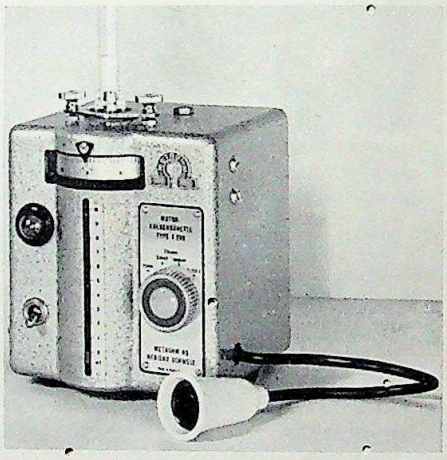

Figure 7. (Courtesy of Brinkmann Instruments, Inc., 115 Cutter Mill Rd., Great Neck, N. Y.) A tailor-made micrometer screw device with decimal readout and manual or motor driven piston buret capable of delivering macro as well as micro quantities.

scale division of the dial corresponds to 0.2 to 5.0 μl. Since there are 1000 divisions these correspond to total capacities of 0.2 to 5.0 ml, respectively. The assembly is mounted on a base to simplify titrations. Several useful accessories are available in cluding a magnetic or rotary mixer.

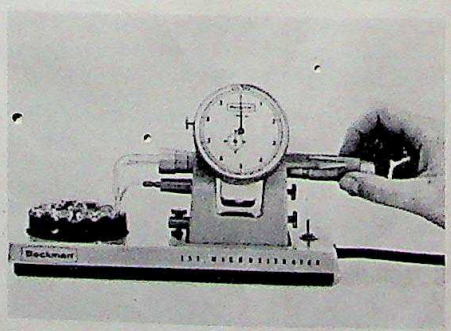

Figure 8. (Courtesy of Beckman Instruments Inc., Spinco Div., Stanford Industrial Park, Palo Alto 7, Calif.) A dial indicating type with gasketed reservoir and Kel-F plunger. Employs a vibration stirrer for agitating the solution during titration.

(Continued on page 504A)

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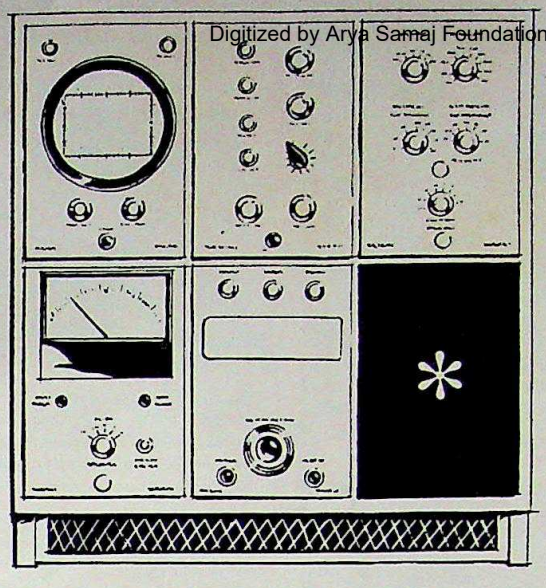

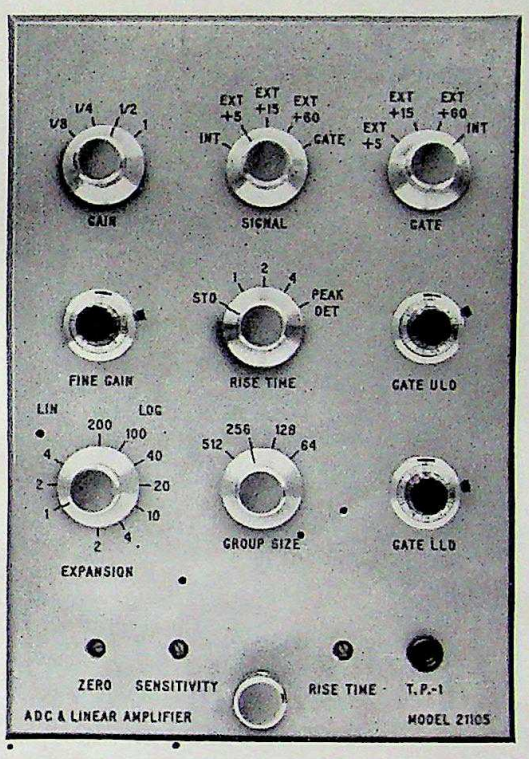

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Mechanical Counter Types

In Figures 10 and 11 are two examples of a unitized mechanical counter and gasketed reservoir. Figure 10 is a compact microtitrator employing a glass plunger so as to eliminate the need of mercury as a secondary fluid. It has a total capacity of 200 μl in 0.02 μl divisions. Mixing of the solution is accomplished by a built-in rotating device.

Figure 11 is an assembly employing mercury as a secondary fluid. Stirring is effectively done with a stream of air or gas. Three sizes are available; namely, 1.0 ml in 0.2 μl divisions, 0.1 ml in 0.02 μl divisions and 0.01 ml in 0.002 μl divisions

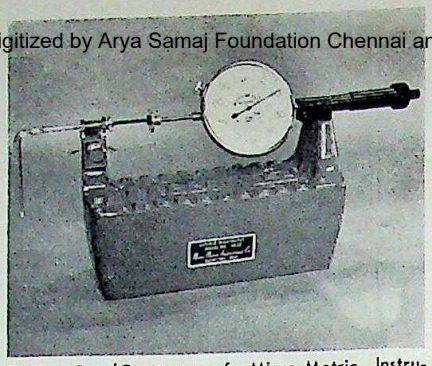


Figure 9. (Courtesy of Micro-Metric Instruments, Inc., PO Box 884, Cleveland 22, Ohio.) A dial indicating type with syringe. Available with accessory for magnetic stirring of solution.

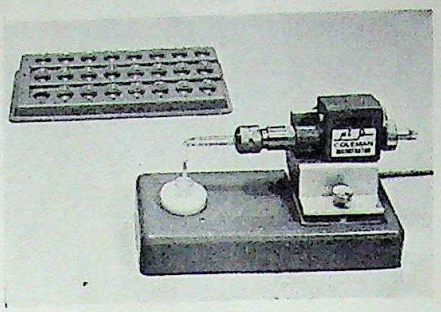


Figure 10. (Courtesy of Coleman Instruments, Inc., 42 Madison St., Maywood, Ill.) A compact combination of mechanical counter and gasketed reservoir. Employs a simple rotating device for stirring.

A motorized rendition of the mechanical counter type is the subject of Figure 12.

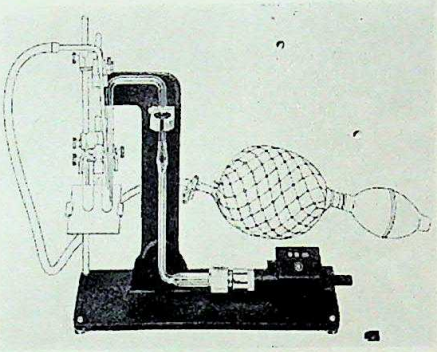


Figure 11. (Courtesy Manostat Corp., 20 N. Moore St., New York 13, N. Y.) A combination of mechanical counter with gasketed reservoir employs a stream of air or gas bubbles for simple and effective stirring.

A standard five wheel counter with zero reset gives convenient reading to 0.1 μl with the 3.2 ml total capacity reservoir. A larger size reservoir of 32.0 ml capacity

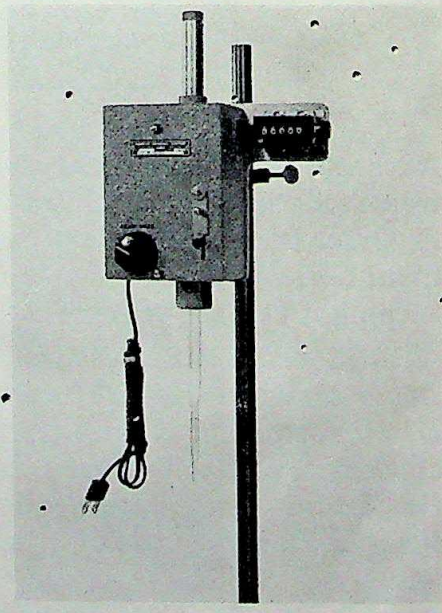
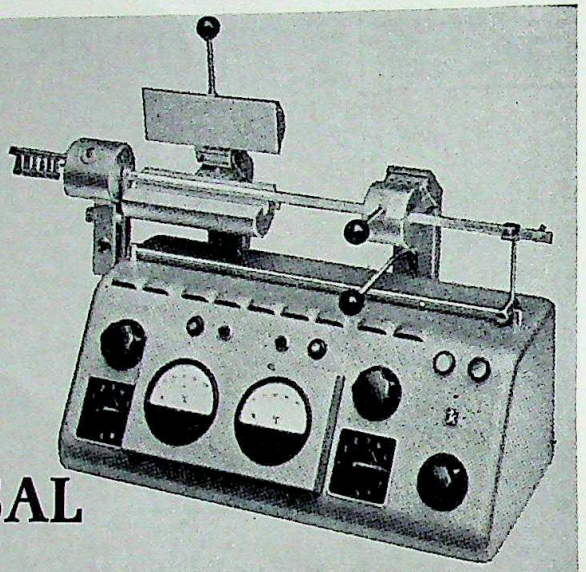


Figure 12. (Courtesy of American Instrument Co., Inc., 8010-8020 Georgia Ave., Silver Spring, Md.) A motor-driven combination of mechanical counter and gasketed reservoir. Employs a Vycor plunger for added accuracy.

(Continued on page A506)



IKA
UNIVERSAL
AUTOMAT

MICRO COMBUSTION TRAIN

permits faster and more accurate determinations of C, H, N, O, S and Halogens with controlled temperature to 1200°C.

Both heaters are hinged for easier insertion and removal of combustion tube and to provide faster cooling.

All controls are on the front panel with separate temperature indicators for long and short heaters. The heater elements are imbedded in ceramic to prevent breakage and oxidation.

The Universal Automat may be used for semi-micro determinations by merely interchanging heaters.

SPECIFICATIONS

Long heater 200 mm. Provides temperatures up to 1200°C within 20 minutes. Cooling time from 1200° to 180°C in 10 minutes.

Short heater 45 mm. Provides temperatures up to 1200°C within 8 minutes. Cooling time from 1200° to 50°C in 10 minutes.

Short heater travel time variable from 5 to 30 mm per minute

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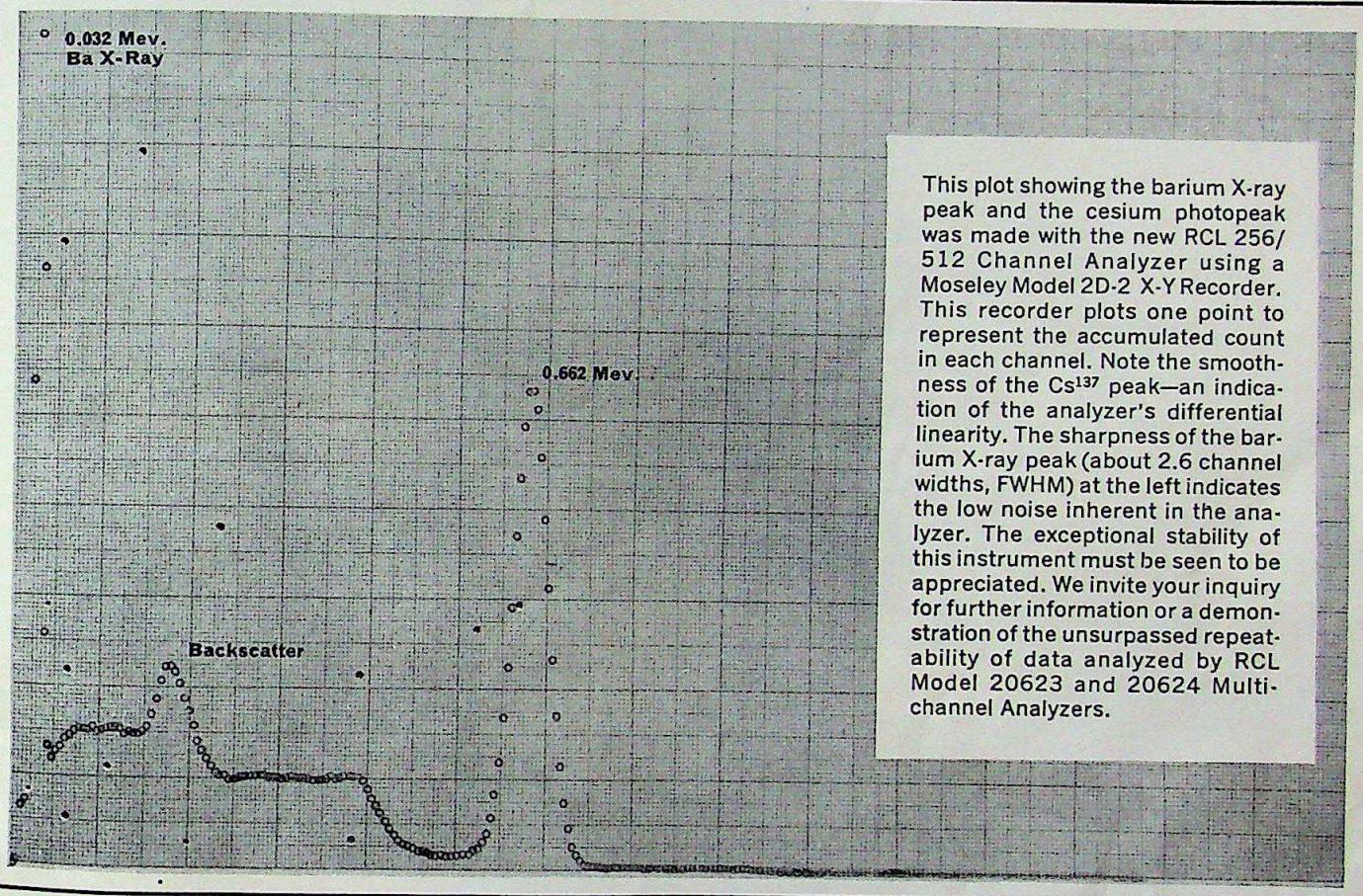
HERE'S PROOF!

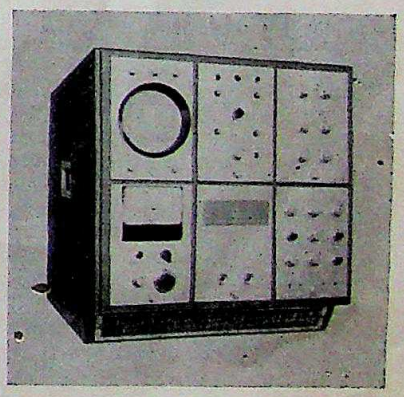
NEW RCL ADC SETS STANDARD FOR MULTI-CHANNEL ANALYZERS



This plot showing the barium X-ray peak and the cesium photopeak was made with the new RCL 256/512 Channel Analyzer using a Moseley Model 2D-2 X-Y Recorder. This recorder plots one point to represent the accumulated count in each channel. Note the smoothness of the Cs^{137} peak—an indication of the analyzer's differential linearity. The sharpness of the barium X-ray peak (about 2.6 channel widths, FWHM) at the left indicates the low noise inherent in the analyzer. The exceptional stability of this instrument must be seen to be appreciated. We invite your inquiry for further information or a demonstration of the unsurpassed repeatability of data analyzed by RCL Model 20623 and 20624 Multichannel Analyzers.

Superior linearity and stability are designed into the new RCL Model 20623 (256 channel) and Model 20624 (512 channel) analyzers. The new analyzers will accept an unprecedented range of input pulse waveshapes and signal levels. One channel is used to store clock pulses and all other channels in the group are useable. These analyzers have two unique features. An expansion control allows detailed examination of the top quarter or half of the energy range. A logarithmic expansion of the energy scale can be made, permitting a full spectrum survey with excellent resolution and linearity over the full energy range. Memory modules are interchangeable (256 or 512 channels) and provide sub-groups in multiples of 64 channels.

In addition to direct display on the self-contained five inch oscilloscope, data may be read out on most conventional devices, including strip chart recorders, X-Y recorders, the IBM typewriter, the RCL Model 21016 Digital Printer, and magnetic or paper tape systems. For complete specifications write: Analyzer Sales Section, Radiation Counter Laboratories, Inc.



RCL RADIATION COUNTER LABORATORIES, INC. A SUBSIDIARY OF ALLIED RESEARCH ASSOCIATES, INC.

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Fischer & Porter Co.

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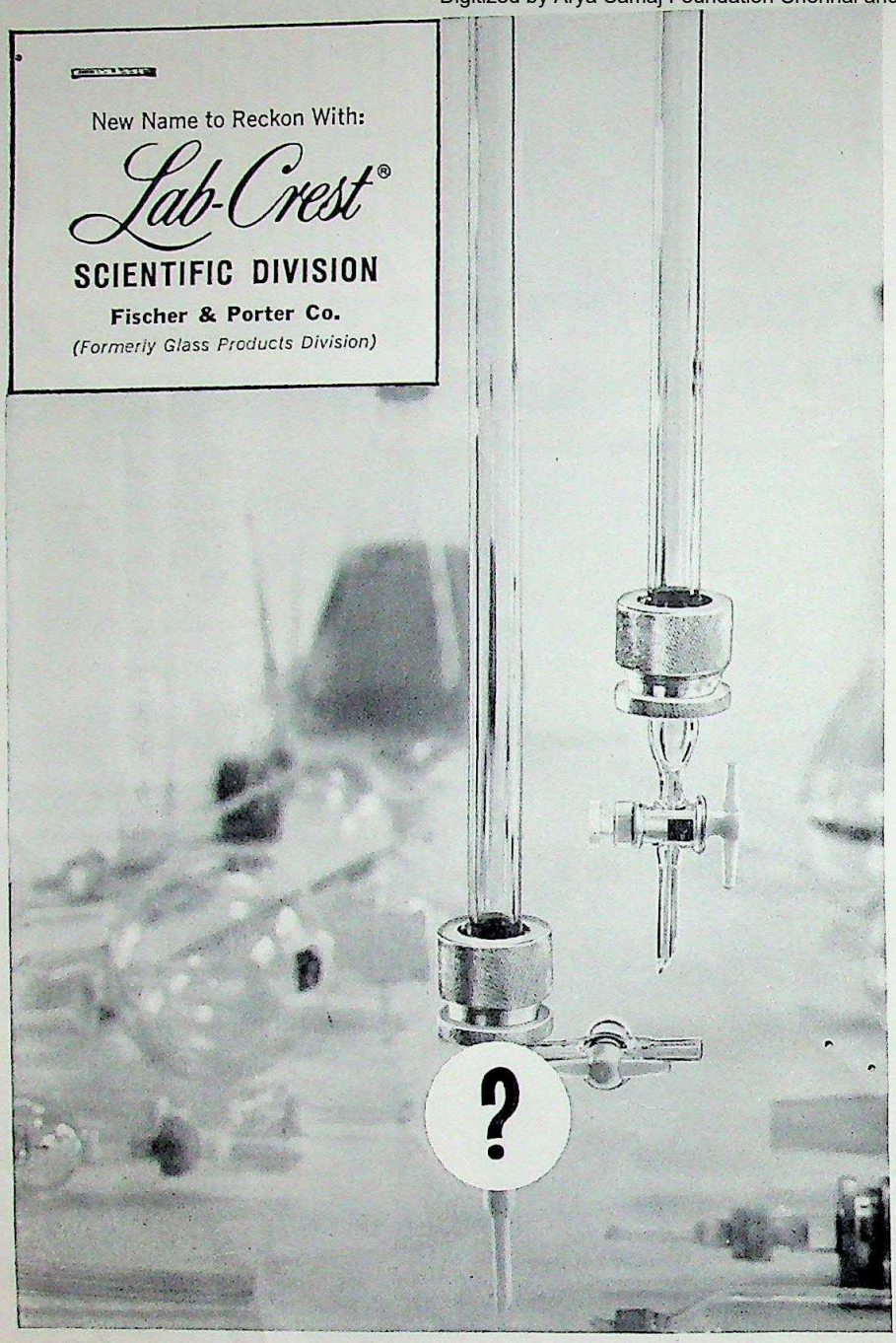

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Today, we catalog several thousand scientific problem-solvers. Some are standard labware. Some, like the grease-less, freeze-less Lab-Crest® Teflon stop-cock and Ultramax® Teflon valve, are exclusively ours. All of them, old and new, are highly versatile.

Case in point: the precision-bore chromatographic columns shown above. We make six basic types that you can mix and match with a whole batch of accessories (stopcocks, valves, inlet and outlet tees, and funnels) to meet your needs exactly.

What's behind the question-mark? Last time we looked, it was a brand new needle valve, especially suitable for gas chromatography. (Write for details.) But it **could** be whatever you need. Just tell us your problem. That's our business: solving labware problems.

Lab-Crest® SCIENTIFIC DIVISION

FISCHER & PORTER COMPANY, 3373 County Line Road, Warminster, Pa.

reading to 1 μl can be attached as an accessory. Buret and syringe tips are also available. Two motor drives are available: a constant speed with synchronous motor and a variable speed type. A Vycor plunger of high uniformity in cross section provides maximum accuracy and eliminates the need of mercury as a secondary fluid.

Microgasometers

A group of microgasometers employing micrometric devices is given in Figures 13 through 17. Examples of the micro Van Slyke apparatus are shown in Figures 13 and 14. The first is a manometric

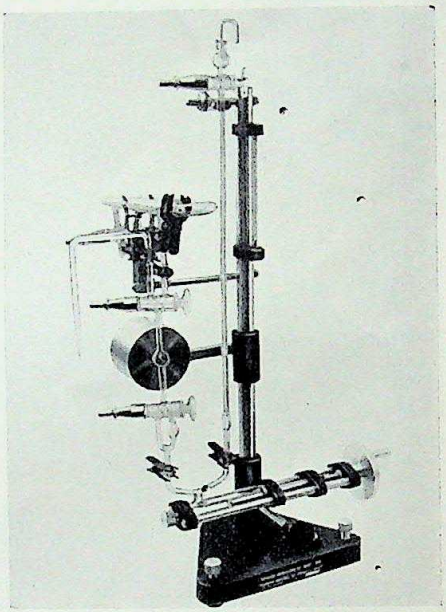

Figure 13. (Courtesy of Scientific Industries, Inc.) Utilizes the micrometer screw and gasketed reservoir to obtain a microgasometer of high accuracy and convenience of operation.

type and the second is a volumetric type. Strictly speaking the micrometric screw of the manometric type shown in Figure 13 does not measure any volumes since it

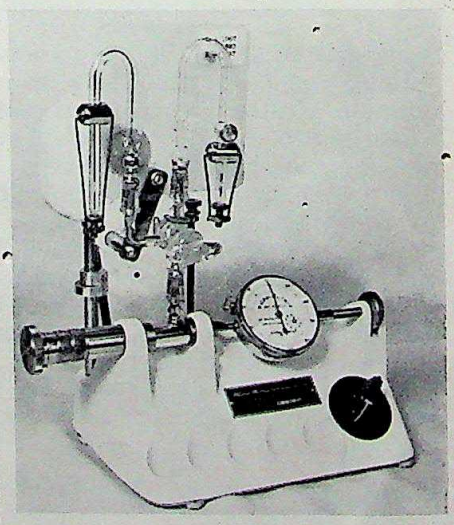

Figure 14. (Courtesy of Micro-Metric Instrument Co.) An ultra-microgasometer employing a dial indicator and gasketed reservoir.

(Continued on page A508)

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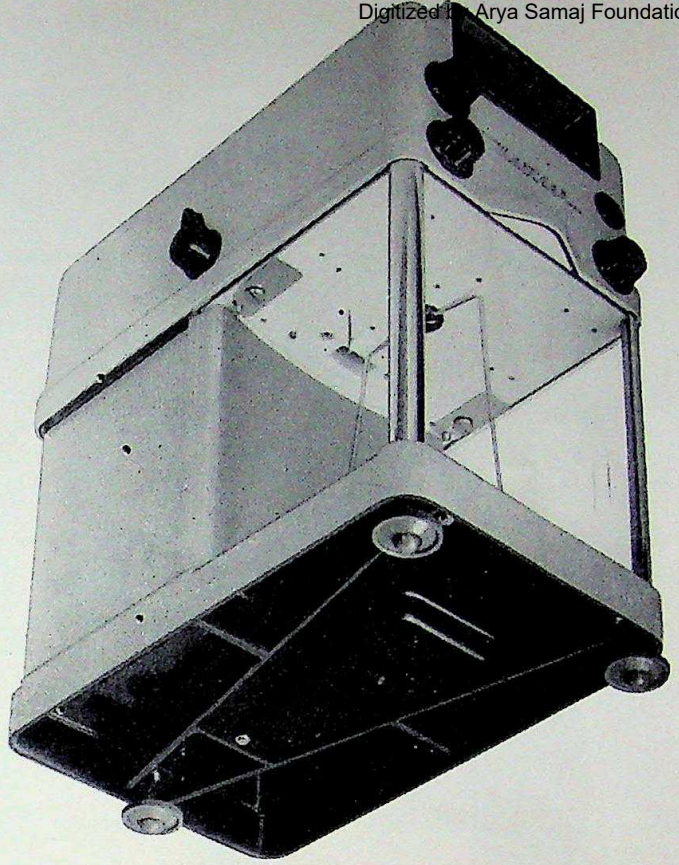

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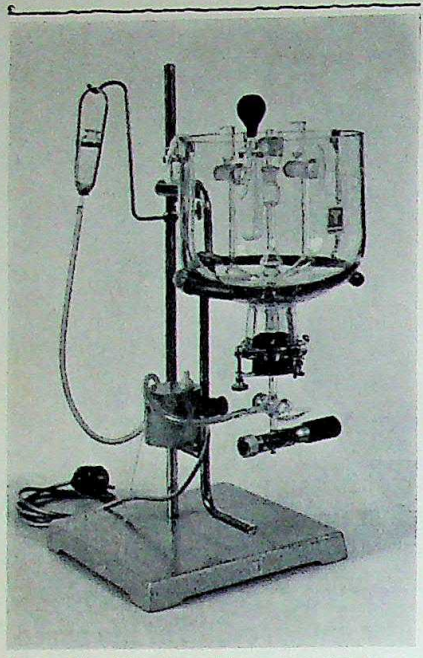


Figure 15. (Courtesy of Instrumentation Assoc., Inc., 17 W. 60 St., New York 23, N. Y.) An ultra-microgasometer assembly utilizing a micrometer screw in combination with a gasketed reservoir.

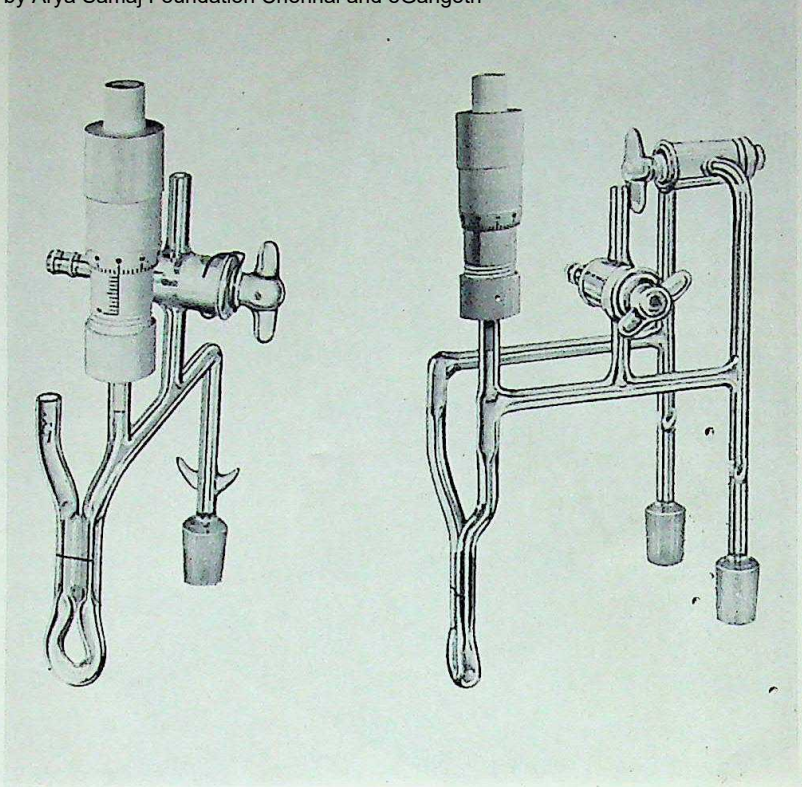


Figure 16. (Courtesy of Roger Gilmont Instruments, Inc.) A micrometer screw adaptation of the Warburg and Differential micro-respirometers.

employs the measurement of pressure at constant volume to provide for the analysis. It has been included here since it basically meets the requirements of combining a micrometer screw and gasketed reservoir.

An example of the ultra-micro Scholander gas analysis device is the subject of Figure 15. The complete assembly is mounted in a water bath to reduce errors that may arise due to temperature change. Volumes are measured with a standard micrometer head.

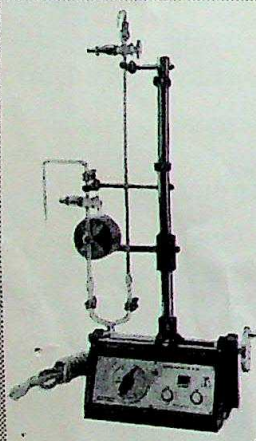
(*Continued on page A510*)

the NATELSON

MICROGASOMETERS

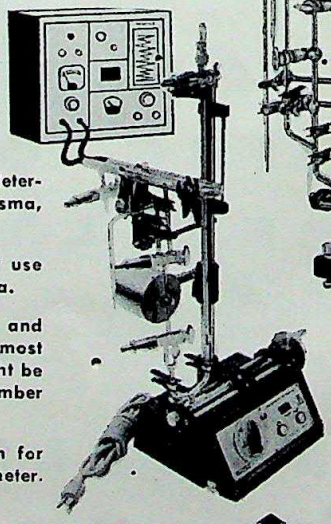
for Gas Determinations of Ultra-Micro Samples

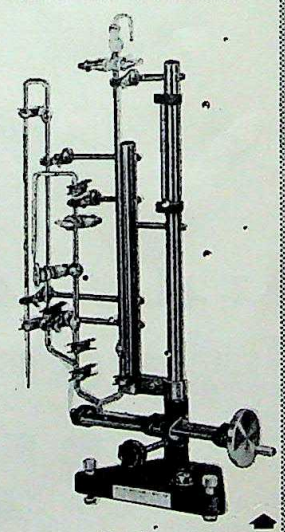
EASY TO LEARN! Natelson Microgasometers adapt the classical Van Slyke manometric method to ultra micro analysis. Improvements in technique, sampling, accuracy and ease of operation have been developed while achieving this adaptation.



Motorized Natelson Microgasometer Model #650.

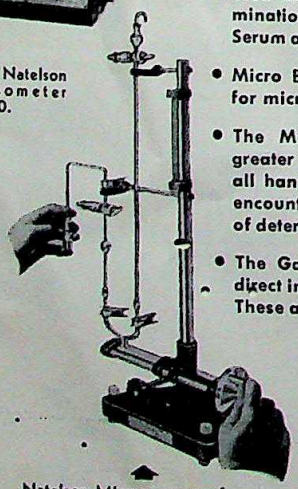
- 0.03 ml. sample provides accurate quantitative determinations of CO_2—O_2—CO—N_2 in Blood, Plasma, Serum and Ammonia.
- Micro Burette attachment enables Microgasometer use for micro titrations such as Chlorides and Ammonia.
- The Motorized Microgasometer features speed and greater reproducibility of results by eliminating almost all hand manipulation and the fatigue which might be encountered in continual operation when a great number of determinations are to be run.
- The Gas Injector attachment provides the system for direct injection of gases liberated in the Microgasometer. These are fed into a Gas Chromatograph.





Natelson Microgasometer Model #600 shown with Micro Burette attachment #M-373-12.

Motorized Natelson Microgasometer Model #650 shown with Gas Injector attachment #M-373-25 as it would be utilized with any Gas Chromatograph apparatus.



Natelson Microgasometer Model #600.

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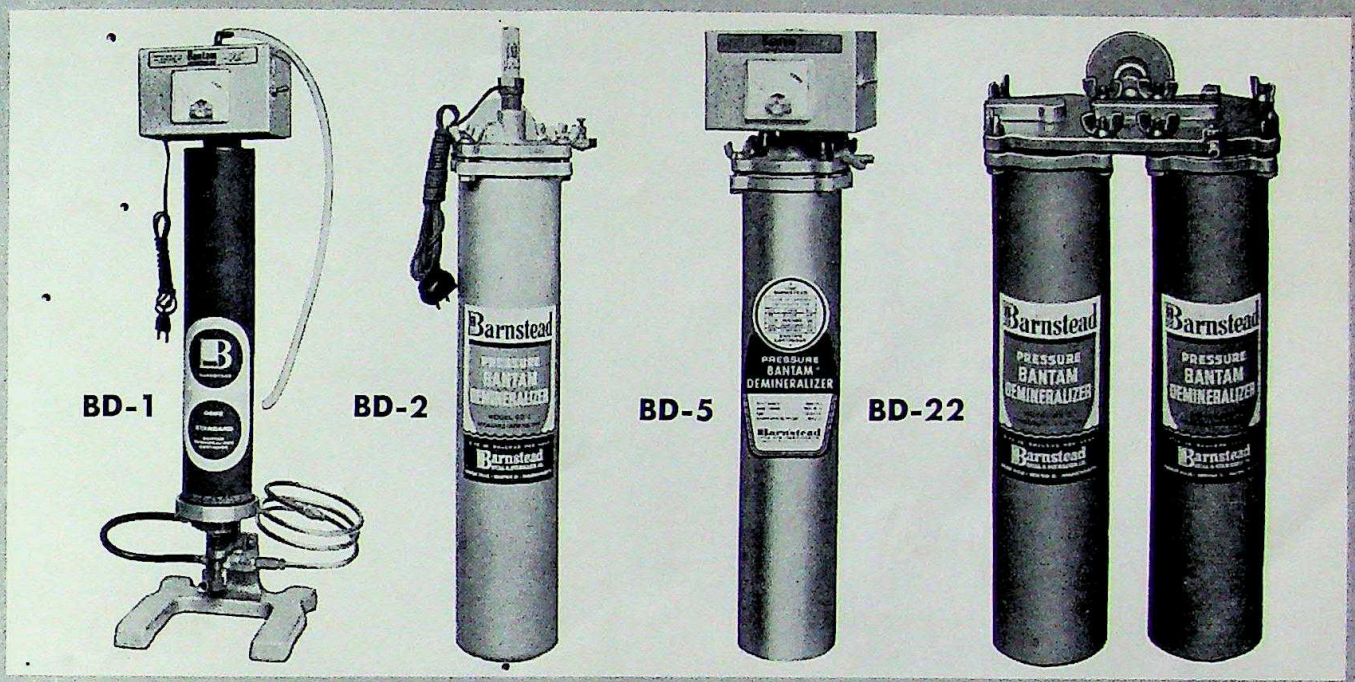

BD-1 WITH DIRECT READING METER

Connects directly to your raw water supply and delivers demineralized water in continuous flow of from 5 to 10 gallons per hour at atmospheric pressure. Direct reading meter shows water purity at all times. Disposable type cartridge may be changed in seconds — no tools needed. Bench or wall mounted.

BD-2 FOR PRESSURE OPERATION UP TO 60 PSIG

Recommended where demineralized water is needed under pressure up to 100 psig. Pura-Lite goes out when cartridge needs changing. Delivers 5 to 25 gallons per hour. Supplied with flange for wall mounting. Measures only 8" x 7" x 24" high. Cartridge easily replaced by removing 4 wing nuts.

BD-5 PRESSURE OPERATION AND DIRECT READING METER

Combines pressure operation with convenience of direct reading meter . . . calibrated 0-15 ppm with equivalent readings in ohms resistance from 25,000 to infinity, making possible constant control over water purity. Delivers 5 to 25 gallons per hour. Pressure operation up to 100 psig.

BD-22 TWO-STAGE PURIFIER

Developed for pure water rinse and cooling systems and other applications requiring two different types of cartridges in series. IE: oxygen removal cartridge with mixed-resin cartridge to produce ion free water with low oxygen content. Tell us your problem and we'll make recommendations.

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WRITE: For Bulletin No. 154. It describes all Barnstead Demineralizers and complete line of cartridges.

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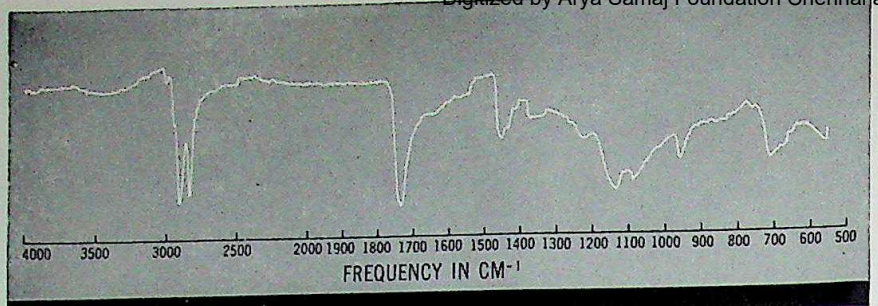

Spectrum of oleomargarine produced by Attenuated Total Reflectance Accessory used with Model 421 Perkin-Elmer Infrared Spectrophotometer

NOW—IR ANALYSES THAT USED TO BE IMPOSSIBLE—WITH NEW ATTENUATED TOTAL REFLECTANCE ACCESSORY

Many materials that have been difficult—or impossible—to analyze by standard infrared sampling methods are no longer a problem. Perkin-Elmer's new Attenuated Total Reflectance Accessory easily accommodates opaque solids, highly viscous liquids, aqueous solutions, and samples of infinitesimal size.

Designed for use with all standard Perkin-Elmer Infrared Spectrophotometers, the A.T.R. unit utilizes the phenomenon of energy reflection at the interface of two materials of different refractive indices. The sample to be analyzed is placed in intimate contact with a polished crystal of known optical properties. Infrared energy, reflected from the sample through the crystal, changes in intensity as the frequencies are scanned. This variation occurs at the locations of the sample's normal infrared *absorption* bands—and to relatively the same degree. Spectra produced by this type of analysis are easily interpreted by conventional infrared methods.

So—if it's linoleum or skin—tincture or aqueous solution—a feather or a pickle—A.T.R. can analyze it for you. To get more details about this revolutionary new sampling technique, with spectra, write to Instrument Division, Perkin-Elmer Corporation, 870 Main Avenue, Norwalk, Connecticut.

Two modifications of the Warburg microrespirometers are shown in Figure 16. These are essentially volumetric devices that measure gas changes at constant pressure. Volumes are measured on an all-plastic micrometer head that has a capacity of 200 μl in 0.2 μl divisions. They have been designed to fit on the standard Warburg baths. For maximum accuracy, a differential model has also been developed.

An example of a more sophisticated instrument is illustrated in Figure 17. It is an automatic combustion apparatus for nitrogen analysis by the classical

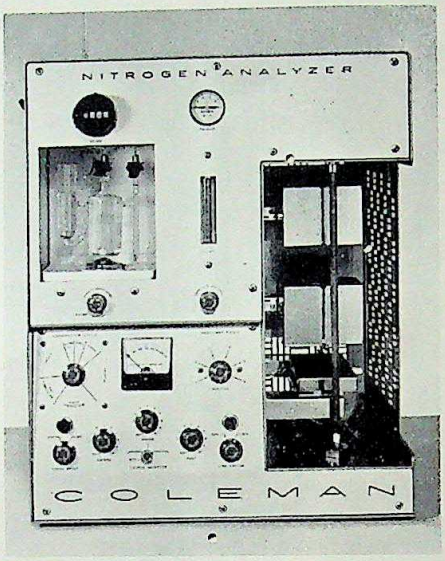

Figure 17. (Courtesy of Coleman Instruments, Inc.) An automatic micro Dumas apparatus employing a mechanical counter and syringe for digital readout of collected nitrogen gas.

Dumas method. The volume of nitrogen is directly given in ml up to 5 ml readable to 1 μl on the digital counter. The nitrogen is collected over mercury and measured in a syringe cavity by the mechanical counter automatically driven by the micrometer screw. Operation is fully automatic eliminating all of the time consuming manipulations required by this method.

Literature Cited

(1) Emich and Wermuth, "Handbuch der Arbeitsmethoden in der anorganischenChemie," Vol. II, No. 2, p. 671, Walter de Gruyter, Berlin and Leipzig, 1925.
(2) Dusing, *Chem. Fabrik.* No. 35/36, 313 (1934).
(3) Scholander, *Science*, 95, 177 (1942).
(4) Scholander and Evans, *J. Biol. Chem.*, 169, 551 (1947).
(5) Trevan, *Lancet*, 202, 786 (1922).
(6) Dean and Fetcher. *Science*, 96, 237 (1942).
(7) Hadfield, *J. Soc. Chem. Ind.*, 61, 45 (1942).
(8) Gilmont, *Anal. Chem.*, 20, 1109 (1948).
(9) Gilmont, *Ibid.*, 25, 1135 (1953).
(10) Lazarow, *J. Lab. and Clin. Med.*, 35, 810 (1950).
(11) Lingane, *Anal. Chem.*, 20, 285 (1948).

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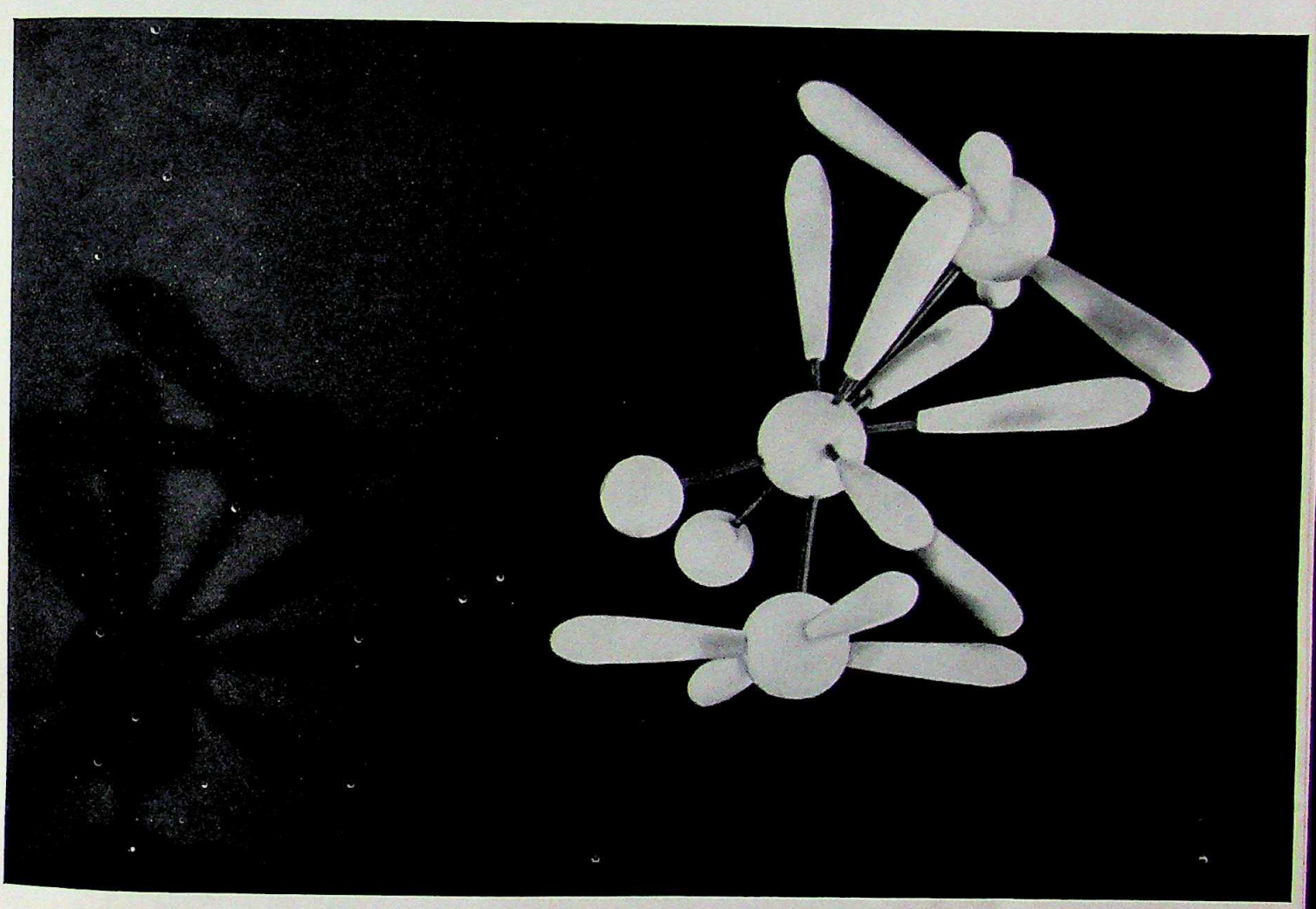
from abstract ideas . . . fundamental knowledge at Esso Research



A new complexing agent for SO_3, which successfully reduces the SO_3 activity and permits continuous precise control over a wide range of activity, has been discovered. These complexes, which are also *organo-soluble*, have resulted from work by Dr. A. F. Turbak of Esso Research on the electron donor capacities of alkyl phosphates with SO_3. Some of the phosphate orbitals available for interaction with SO_3 are illustrated in the molecular model shown above.

Apparently, the phosphate binds the SO_3 almost as tightly as pyridine since a 1/1 molar complex will not attack aromatic rings even at 75°C, but will sulfate alcohols at ambient temperatures. The same complex reacts smoothly with organometallic compounds to yield sulfonates or sulfates on hydrolysis.

$$(\text{Ø}CH_2CH_2)_3Al \longrightarrow 3\text{Ø}CH_2CH_2SO_3H \text{ or}$$
$$(C_8H_{17}O)_3Al \longrightarrow 3C_8H_{17}OSO_3H$$

The SO_3 function is positioned exclusively at the carbon atom previously attached to the metal.

By increasing the ratio of SO_3 to phosphate, aromatic rings can be sulfonated smoothly *without sulfone cross-link formation*. Thus, polystyrenes of 3-5 million molecular weight have been sulfonated to water soluble products.

Under proper conditions, direct sulfoesterification of aromatics can also be achieved.

$$R\text{Ø} + (EtO)_3P \overset{-}{\underset{+}{=}} O \cdot SO_3 \longrightarrow R\text{Ø}SO_3Et$$

These studies lead to a new appreciation of the electron donor capacities of phosphates and suggest that these agents could be used to solubilize and control other electron deficient systems.

. . . adapted from the scientist's notes at
Esso Research and Engineering Company
(P. O. Box 45B, Linden, New Jersey)
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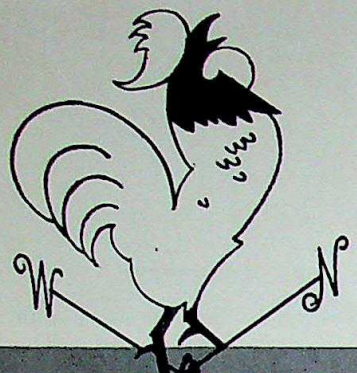

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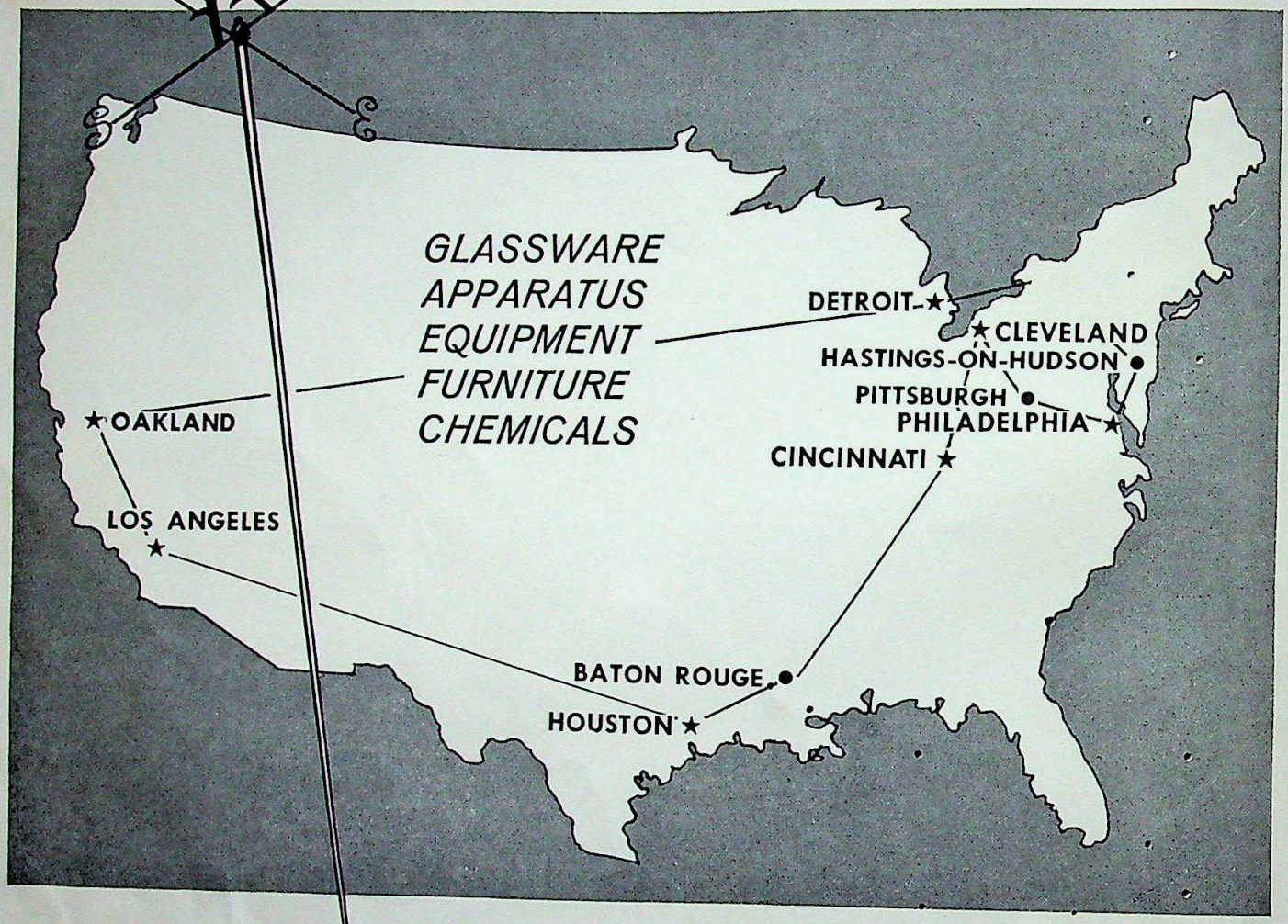

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Chem Ed

Out of the EDITOR'S BASKET

Edited by William G. Kessel

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New Apparatus and Equipment

▶ The time-consuming work of "spotting" or "striping" paper chromatograms can be reduced greatly by using TechniLab Instruments' new Chromatography Spotter. As many as 8 spots or stripes can be applied at one time—automatically—on the same or separate papers. For details, write to TechniLab Instruments, 2231 S. Carmelina Ave., Los Angeles 64, California.

▶ A high accuracy weight determination scale has been developed by Thayer Scale Div. of Cutler-Hammer, Pembroke, Massachusetts. The scale, having a resolution of 2 parts in 100,000, compares loads of unknown value with master standard test weights. Scales are available in ranges of 0–1000 g up to 100–4000 lb. Applications include establishing specific gravity by weighing in air then in water, in the laboratory, or on a production basis.

▶ New Royco Model 230 aerosol photometer measures and indicates total average logarithm of light scattered by large number of particles in sample stream. It thus provides a reading of relative aerosol concentration in monodisperse aerosols or in aerosols having constant spectra of sizes present. Contact James Weersing, 440 Olive St., Palo Alto 6, California.

▶ The HR-97 is a high performance 11 × 17 inch X-Y recorder priced lower than most 8½ × 11 in. recorders. Emphasizing a straightforward design approach, the HR-97 has 1 mv/in. basic sensitivity, 0.25% of full scale accuracy, 15 in./sec pen speed, zener reference voltages, snap-on pen assembly, and vacuum paper holddown. Write the Houston Instrument Corp., 4950 Terminal Ave., Bellaire 101, Texas.

▶ Tracerlab's four-pi scanner, model SC-525T, consists of two high-efficiency radiation detectors similar to those used in the division's low-background counting systems, a dual rotating collimator, ratemeter, high-voltage power supply, and strip-chart recorder. Details are available on request from Tracerlab, 1601 Trapelo Rd., Waltham 54, Massachusetts.

▶ A new laboratory spectrophotometer, the Coleman Autoset, was recently introduced by Coleman Instruments, Inc., 42 Madison St., Maywood, Illinois. Designed for application in research, as well as routine analytical work, the instrument covers the ultraviolet, visible, and near-infrared regions of the spectrum, from 200 to 1000 millimicrons.

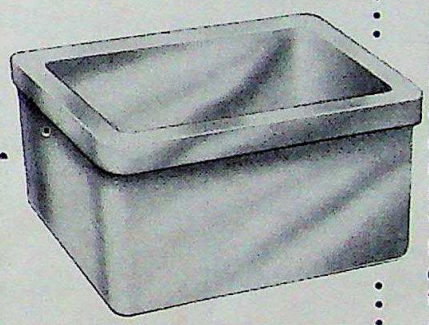
▶ Analysis of small quantities of high absorbance samples can be conveniently performed in the UV and visible regions of the spectrum with the new short path UV microcell just introduced by Limit Research Corp., P.O. Box 852, Darien, Connecticut.

▶ Designed to produce intense homogeneous fields over a large volume, Alpha's new aluminum strip wound solenoid coils provide an efficient magnetic field suitable for many requirements. This solenoid is one of a standard series of solenoid coils produced by Alpha, which are capable of providing fields up to 20 kilogauss. Write J. W. Bodnar, P.O. Box 333, Berkeley 1, California, for additional information.

▶ Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Massachusetts, has added to its line of atomic instruments an all-transistorized single-channel spectrometer. The model 530 features all presettable

(*Continued on page A515*)

"U. S." CHEMICAL PORCELAIN LAB SINKS



THE LAB SINKS WITH THE

Lifetime Guarantee

The laboratory sinks which we manufacture from chemical porcelain are completely impervious and corrosion-proof. Their resistance to all corrosive agents (except hydrofluoric acid) is not limited to the glazed surfaces. Both the glaze, and the sink body itself, are made of the same basic corrosion-proof materials. Thus, there is practically no difference between the corrosion resistance of the glaze and that of the sink body.

We, therefore, make the following guarantee:

We guarantee, for the life of the building in which it is installed, that this sink will not be destroyed by the action of corrosive agents, regardless of whether glazed or unglazed surfaces are exposed to corrosion.

We also guarantee that this sink will not be damaged or destroyed by temperature changes or mechanical stresses encountered in normal laboratory usage.

(This guarantee does not include mechanical damage due to gross carelessness during installation or due to heavy impact, nor does it include etching of the sink surface by hydrofluoric acid. Natural and artificial silicates are attacked by hydrofluoric acid, and if such acid is emptied into sinks, the sinks should be flushed with water immediately to prevent damage to the glaze.)

Under the terms of this guarantee we will furnish without charge, freight prepaid, a new sink for any sink which fails to meet the service warranty above. This guarantee does not include any installation costs. We reserve the right to request the return of the defective sink, freight collect.

For complete details contact your Laboratory Furniture Manufacturer or write direct for free Bulletin L-10.

Chemical Ceramics Division

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AKRON 9, OHIO

82-H-3

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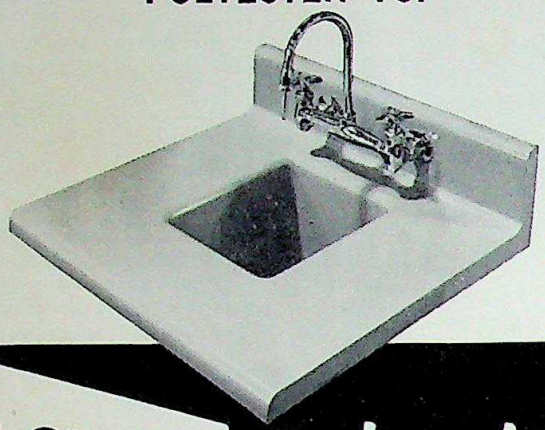

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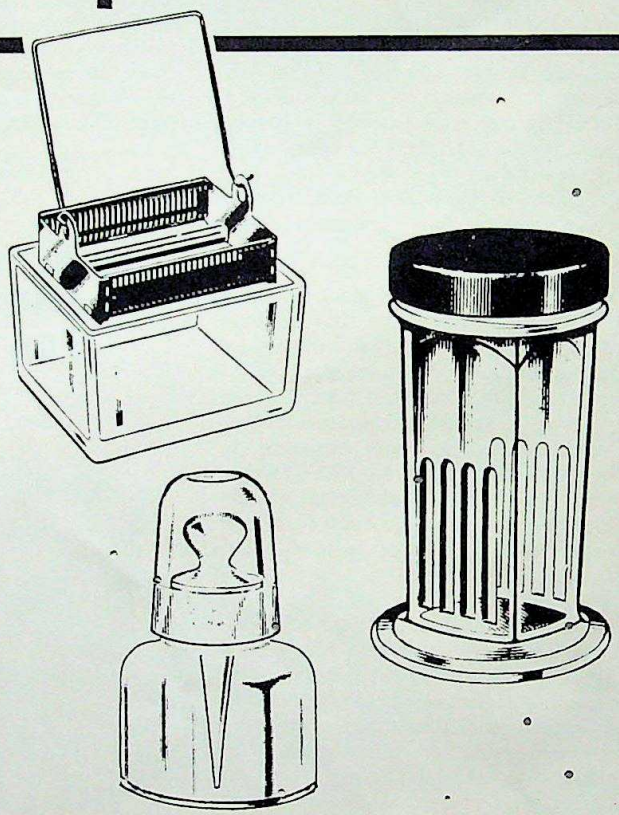

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decades on the six-digit scaler and five-digit timer, plus a choice of minutes or seconds on the timing ranges. The amplifier section has two inputs, current and voltage.

▶ A new scientific instrument makes possible rapid and highly accurate registration of liquid levels of helium or hydrogen in vessels, cryostats, or Dewars. Its principle of operation is measurement of current change in a carbon resistor, as its resistance changes with temperature. For further information, address Sulfrian Cryogenics, Inc., 1290 Central Ave., Hillside, New Jersey.

▶ Magna Corp., Bldg. 55, 1 Space Park, Redondo Beach, California, announces a new, convenient device that measures dissolved or gaseous oxygen in a matter of minutes. Known as the Model 1070 OxyMeter, this self-energized, compact instrument may be used both in the field and in the laboratory. It consists of a sensor and read-out meter.

▶ Column effluents or other fluid flows can be divided into fractions on a precision time base using the compact new Durrum Model BF preparative fraction collector and liquid distributor. Contact Durrum Instrument Corp., 841 Woodside Rd., Redwood City 2, California, for details.

▶ Radioactivity tracer studies in both petroleum and biochemical analyses have been simplified by the Loenco Model 75 ion chamber oven accessory unit which can be connected to a gas chromatograph. This permits a continuous, simultaneous radioactivity and gas chromatograph analysis of the sample. Write for *Data Sheet Loe-18*, Loenco, Inc., 2092 N. Lincoln Ave., Altadena, California.

▶ Allied Radiation Equipment Co., 250 Fulton Ave., Hempstead, L. I., New York, presents a new "Universal Radiometer," that may be used with all standard photomultipliers operating in the 1000 volt range. The Radiometer has a regulated supply that is insensitive to variations either line or load.

▶ The Cryogem cooler achieves temperatures *at any point* in a 500 degree range from room temperature to 425 Fahrenheit degrees *below zero*. The machine is 12 in. high, measures 3 in. by 3 in. at the base, and weighs less than 12 lb. Write Cryogenerators Division, North American Philips Co., Inc., Ashton, Rhode Island.

▶ Model PAPM-1, the most sensitive commercial monitoring instrument ever developed to detect radioactive airborne plutonium or other long half life alpha emitting isotopes is announced by Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Indiana.

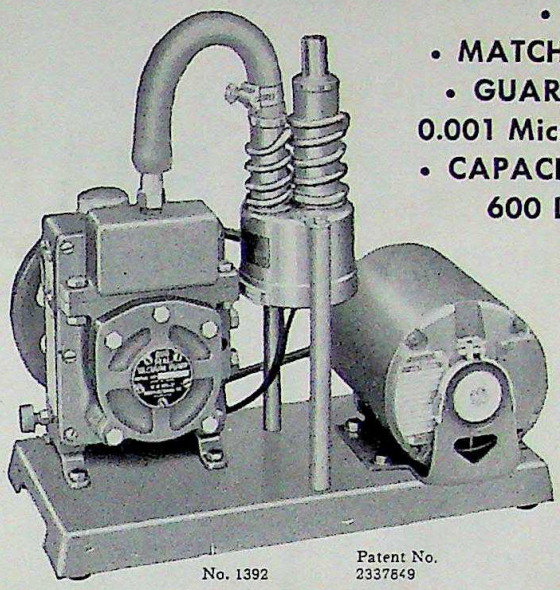
▶ The Pyrometer Instrument Co., Inc., Bergenfield, New Jersey, has announced

(*Continued on page A516*)

Welch **DUO-SEAL MECHANICAL AND DIFFUSION PUMP ASSEMBLY**

EACH ELEMENT WITH TWO-STAGE CONSTRUCTION

WATER-COOLED OR AIR-COOLED MODELS



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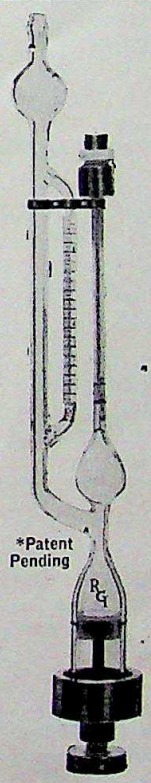

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(.0001—1mm. HG.)

adjustable closed end
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- High precision single linear scale 0-100 mm
- Multiple ranges achieved with adjustable closed end { 0-1 mm in .01 mm; 0-0.1 mm in .001 mm; 0-.01 mm in .0001 mm }
- Closed end easily opened for cleaning
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1. High vacuum "O" ring seal and precision ground rod creates an adjustable closed end.
2. This permits multiple selection of range with a single linear scale.
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7. Compactness and simplicity makes this instrument unique.

JC63647 GAGE McLEOD complete as described above without mercury $52.50

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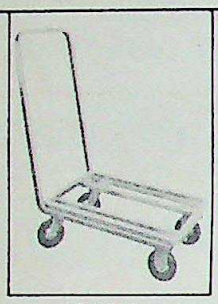
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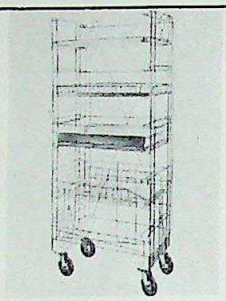
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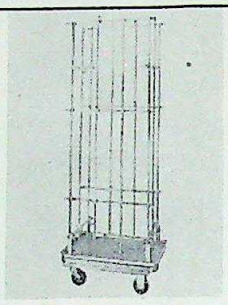
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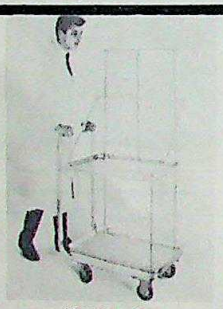
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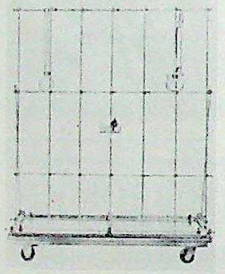
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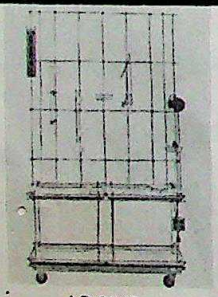
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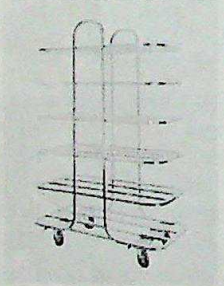
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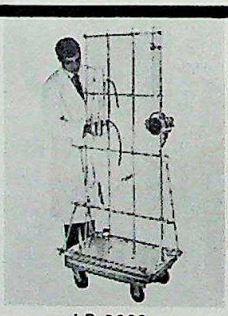
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Out of the EDITOR'S BASKET

an improved Pyro micro-optical Pyrometer, designed specifically for precision temperature measurements above 700°C in the laboratory, yet sufficiently portable to be used for general plant applications.

▶ A new, mechanically refrigerated, portable, low temperature, bath and chamber has been developed by Thermovac Industries Corp., 654 Henry Street, Brooklyn 31, New York. This bath and chamber is completely mechanically refrigerated, and provides temperatures to −60°F.

▶ Liquid-liquid chromatography is now beginning to appear as the next most promising branch of the chromatography tree. Problems which could not be solved by gas or gas-liquid chromatography can be solved by the new Waters gel permeation chromatography assembly which was shown for the first time at the Pittsburgh Conference on Analytical Chemistry. Details are available from Waters Associates, Inc., 45 Franklin St., Framingham, Massachusetts.

▶ Henry Troemner, Inc., 22nd and Master Sts., Philadelphia 21, Pa., announces the availability of two new concepts in their basic Universal laboratory positioner, the "Lab-Arm."

▶ Schuco Scientific, 250 W. 18th St., New York 11, N. Y., announces the availability of its new Thermocool TK-1. The Thermocool introduces a new concept and ease into cooling and refrigerating methods in the laboratory. The Schuco Thermocool TK-1 is a compact, portable refrigerating device which can convert any bath in the laboratory into a refrigerating or cooling unit.

▶ With the introduction of throwaway IR cells by Limit Research Corp., 557 Post Rd., Darien, Connecticut, no longer is it necessary for analytical laboratories to maintain an extensive range of conventional sealed cells. One pack of assorted throwaway cells serves the purpose at a fraction of the cost. Made of silver chloride film, protected by thermosetting plastic covers, the cells are set at six different path lengths from 0.025 to 1.0 mm.

▶ Chemplast, Inc., 3 Central Ave., East Newark, New Jersey, offers a non-staining, dry-lubricating powder of TFE "Teflon" called Fluoro-Glide 200 which imparts the unmatched low friction character of this most slippery of solid materials to all sprayed surfaces. The clean white powder clings electrostatically to virtually all materials, to lubricate efficiently where oils, greases, waxes, and graphite are inefficient or cannot be used.

▶ MicroTek Instruments, Inc., 550 Oak Villa Blvd., Baton Rouge, Louisiana, offers a new electrometer, the research electrometer, with a full scale sensitivity

(*Continued on page A518*)

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Kodak advertises:

ionizable, water-soluble NMR standard . . . the kind of decision where we can help . . . a white polyester fiber, a really white one

The song of the protons

Bright chemists who were six years old in 1946 regard magnetic resonance spectra as just another accretion to the culture, like decimal points or hot pyridine. In that year physicists announced that protons in a magnetic field absorb energy from radiation of the same frequency as the precession rate, which is proportional to the field strength.

Actually it is hard to mount a single proton on the end of a pin. In the real world, the protons in a target are subjected to different field strengths, however uniform the applied field. For one thing, electrons in the vicinity of a proton act as little magnets themselves and affect the proton's magnetic environment. But on the average, a proton on the third carbon from the end in a certain molecule finds itself in the same magnetic situation as the proton on the third carbon from the end in another molecule of the same substance in the same liquid sample. Furthermore, their common situation differs significantly from that of a proton linked in a hydroxyl group to an electron-greedy oxygen atom that keeps pulling the orbital covers off.

Chemists got the point very quickly, thanked the physicists, and took over. Today a central chemical research laboratory without a nuclear magnetic resonance outfit simply doesn't belong to the club. Ours belongs to the club.

Nuclear magnetic resonance service with a smile is available to anybody working in our central lab who is pretty sure of the molecular structure of the contents of a little bottle he carries into Room 258 but would prefer to be a little surer. He comes away with a roll of paper bearing a plot of energy absorbed at 60mc *vs.* magnetic field. One very sharp, high peak at the end of the spectrum is a reference line from tetramethylsilane, $(CH_3)_4Si$, which one mixes in with the sample because it's loaded with protons that are uniformly and heavily shielded by electrons. It has become customary to refer to resonances by how far down they come from the TMS line.

It is too bad that TMS is virtually insoluble in aqueous and ionic solution. Recently the inventor of the TMS gambit fixed this by replacing one of the methyls with a propanesulfonyl.

Inevitably, thank goodness, there arrived a letter which attempted to persuade us that this ionizable, water-soluble version "might be of greater interest to NMR spectroscopists around the country if it were more readily available." Within the week, we replied that production of the requested compound was under way, closing: "Thank you very much for bringing this product to our attention, as we sincerely appreciate knowing what new chemicals are required for today's research."

This was the proper sentiment to express, rather than to admit we had to make it anyway for Room 258. Now it is proper simply to announce that a gram of the compound as 3-(Trimethylsilyl)-1-propanesulfonic Acid Sodium Salt (EASTMAN 8773) *is obtainable for $2.85 from Distillation Products Industries, Rochester 3, N. Y. (Division of Eastman Kodak Company), which happily supplies without charge its List No. 43 of some 4100 other* EASTMAN *Organic Chemicals.*

Price subject to change without notice.

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If among your burdens of office is the need to display wisdom in such decisions as choice of office copiers, we respectfully point out that our brand-new item in that line, the VERIFAX CAVALCADE Copier, involves neither horses nor the pouring of liquids, that it is as automatic as makes sense, that it gives up to seven copies of a document at as low a unit cost and as high a legibility and permanence as you'll find, and that we have too much of an investment in your esteem of us to risk our name on anything you or we might regret.

For the actual pitch, preferably delivered live by a dealer, make your interest known to Eastman Kodak Company, Business Photo Methods Division, Rochester 4, N. Y.

If there is an offset duplicating machine in your department (or if there could be one) and if you were equipped for the KODAK EKTALITH *Method, you could turn out in quantity material enlarged, reduced, or for other reasons photographically copied from the original. About* that, *ask Eastman Kodak Company, Photo Reproduction Products Division, Rochester 4, N. Y.*

Fluorence! Fluorence!

One of us is advertising manager for fibers and faces the problem of explaining to people who make clothes and people who wear clothes what's new and different about KODEL IV Polyester Fiber. One of us has won a bit of recognition for 30 years of research on the psychophysics that underlies color photography and now faces the problem of showing what pertinence the concept of "fluorence," which he discovered and named, bears to life and labor. The two problems solve each other.

Still another of us, who works in England to make photographic paper stay white, focuses his thoughts on chemical mechanisms for soaking up a little energy from the near ultraviolet (near enough to penetrate glass) and re-emitting it just over the line in the visible violet, where all organic fibers tend to drop off a mite in reflectivity. (Your great-grandmother to the contrary notwithstanding, her hankies were never as white as yours; the lost violet wasn't being replaced. When many launderings have removed more of the modern brighteners than the brightener-loaded modern detergents can redeposit, modern spirits sag and dry-goods cash registers tinkle.)

Some of the Englishman's thoughts, passing through Tennessee minds, have now led to a way of permanently building this mechanism into the very structure of the polyester fiber itself. *That's* what's different about KODEL IV Polyester. Its brightness is locked in, which means that for the cash registers to peal out again, the lady must tire of the design, but that can be arranged.

For the current season, white has been decreed from Paris—a good omen, but only now are KODEL IV-bearing fabrics issuing from the mills, and the channels of the garment trade are long and tortuous. We may not catch the white wave, but men's white shirts and women in white for a livelihood will still be around. Women out of uniform will enjoy the fluorence of KODEL IV after white reverts to social acceptability for the well-dressed woman only at oriental funerals. Furthermore, a woman is permitted to combine delicious feminine submission to fickle fashion with intellectual curiosity.

A fluorent color appears to glow of itself. It has no grey in it. This sounds like giddy chatter but isn't. It deals objectively with subjective phenomena. Fluorence is the appearance of fluorescence. Fluorence is psychophysical; fluorescence is physical. We have shown to our own surprise (*J. of the Optical Society of America*, 49, 1049 (1959)) that there can be fluorence without fluorescence and fluorescence without fluorence. Fluorence can be demonstrated and measured at all dominant wavelengths and purities. Fluorence can be either enhanced or suppressed through the dyer's art. Raw KODEL IV Polyester is both fluorent and fluorescent. There is nothing like it on the market.

Ladies (or gentlemen) desiring reprints of the above-cited paper should write to Eastman Kodak Company, Color Technology Division, Rochester 4, N. Y. Eastman Chemical Products, Inc., Kingsport, Tenn., just sells the fiber and talks to the trade.

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Out of the EDITOR'S BASKET

of 10^{-13} amperes and noise and drift of less than 1% of scale. A wide range bucking voltage has been provided which is coupled directly to the input attenuator in order to facilitate use of the equipment with the company's new line of ionization detectors. Also a new detector power supply for gas chromatography. The supply is available in three models with a choice of a 0–2000 volts dc regulated high voltage supply, a combination dc or Rf pulse low voltage supply, or a combination of both of the above supplies.

▶ The availability of a new direct reading Thermistor Thermometer for cryogenic applications is announced by Nuclear Instruments and Controls Corp., Apollo, Pennsylvania.

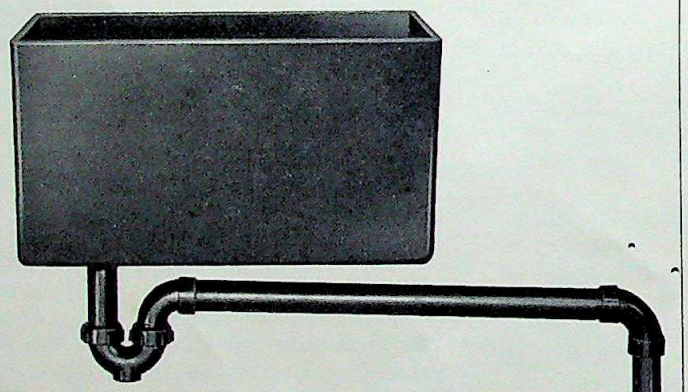
▶ A new combination service center, comprising all of the lighting and service fixtures needed to accommodate as many as four students or technicians, is now being introduced to the laboratory field by Carriker Laboratory Equipment, Inc., Monroe, North Carolina.

▶ Acid squirt-back, seal-failure, and many other hazards associated with pumping acids have been eliminated with the use of Craftneeds rotary pump. This rotary action pump incorporates a unique design not found in other existing pumps today and is available from Craftneeds, Inc., 4477 Eastern Ave., Cincinnati 26, Ohio.

▶ F and M Scientific Corp., Route 41 and Starr Rd., Avondale, Pennsylvania, announces the introduction of the Model 700 gas chromatograph. The Model 700 is a highly efficient dual column instrument incorporating many of the newest concepts in gas chromatographic instrumentation.

▶ It is now possible to dial precisely any desired field intensity in a laboratory magnet air gap with the new Varian magnet power supply, featuring the Fieldial* magnetic field regulator. For complete details, write Magnet Product Group, Varian Associates Instrument Division, Palo Alto 5, California.

NON-STOP THRUWAY FOR CORROSIVE WASTES...



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Send your corrosive waste materials down a non-stop thruway of corrosion-resistant polyethylene. Start with Vulcathene one-piece, molded laboratory sinks . . . they're durable, corrosion-resistant, unbreakable, easily cleaned and they withstand mechanical shock and impact. Add the required Vulcathene traps, pipe, fittings, couplers and adapters . . . joined rapidly, easily and permanently by a patented heat fusion process.

Vulcathene drainline installations are ideal for industrial, educational and research facilities because they handle acids, bases and salts. They're even suitable for potable water supply systems, too.

Vulcathene offers a completely integrated drainline system that's low-cost, light in weight, easy to install; requires no maintenance throughout its long life.

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New Literature

● In conjunction with the manufacture and supply of the broadest range of isotope labeled compounds anywhere available, the Volk organization has developed facilities and techniques which extend its capabilities well beyond simply providing catalogue listed materials. A brochure detailing the many special Volk services is available from Volk Radiochemical Co., 8260 Elmwood Ave., Skokie, Illinois.

● Metalab *Catalogue 6-C* (A.I.A. File No. 35-E), entitled *Laboratory Sink Assemblies, Service Fixtures, and Table Tops,* describes the company's latest line of new, fundamentally designed laboratory accessories. Copies are available from Metalab Equipment Co., 270 Duffy Ave., Hicksville, L. I., N. Y.

● New bulletin on strip-chart recorders describes a linear/log recorder and a high-sensitivity recorder with a sensitivity of 1 microvolt in the ½-millivolt range. An automatic integrator is also illustrated and listed. For copies write to LaPine Scientific Co., 6001 S. Knox Ave., Chicago 29, Illinois.

● A 64-page product catalogue, covering the complete Labconco line of laboratory apparatus and equipment has been released by Labconco, 8813 S. Propect Ave., Kansas City 32, Missouri.

● Penn-Chem Corp., 232 N. Marshall St., Lancaster, Pennsylvania, is making available a complete personalized line of new, fundamentally designed kit (suitable for filing) containing all the current literature, information, and prices on over 90 exclusive Penn-Chem products for the chemical and allied professions. Address requests to Dr. Herbert I. Berman.

● Written by research scientists of Varian's Instrument Division, *Technical Information Bulletin Vol. III, Number 3* contains the following papers: "Operational Considerations with the V-4532 Dual Sample Cavity," "Proton-Proton Spin Decoupling Using the Varian V-3521 NMR Integrator," "NMR Microcell Developments," "A-60 Temperature Controller Calibration," "Proton-Proton Spin Decoupling Apparatus," and "NMR and EPR at Work." Persons interested in receiving this free 16-page bulletin, illustrated with photographs and figures, should write Instrument Division, Varian Associates, 611 Hansen Way, Palo Alto, California.

(*Continued on page A520*)

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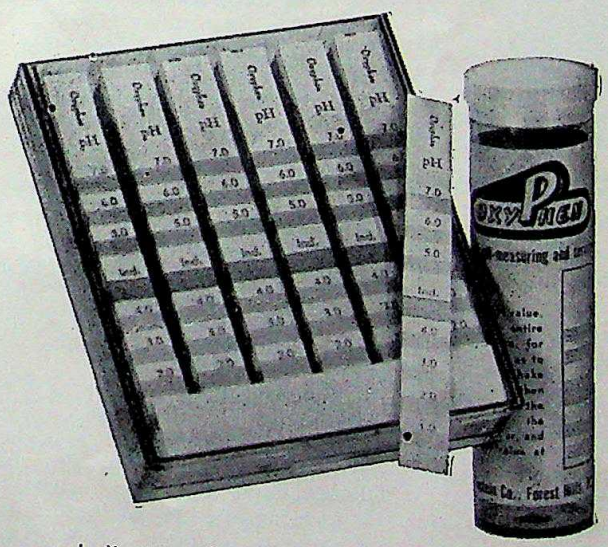

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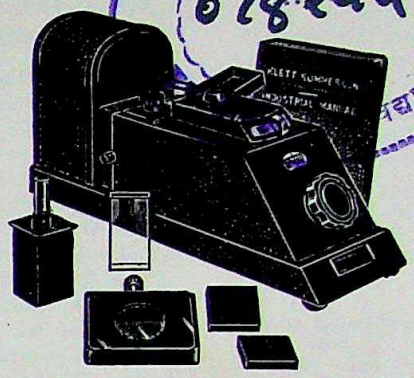

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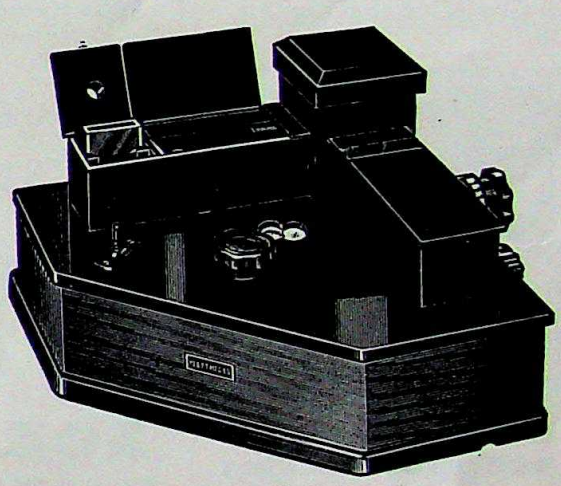

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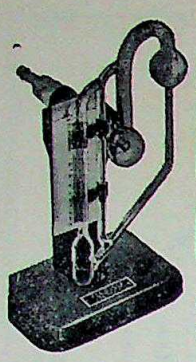

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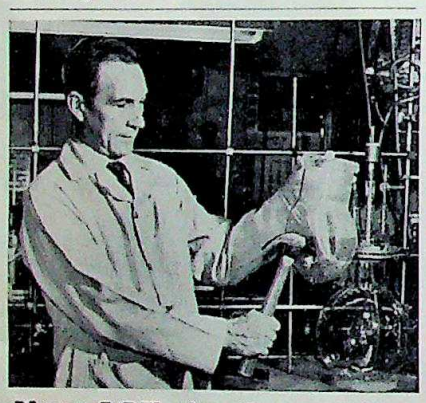

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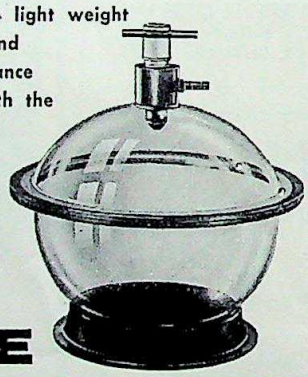

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● Descriptive information on the new RSCo. automatic reagent dispenser and the RSCo. Model 1205 automatic fraction collector is available from Research Specialties Co., 200 S. Garrard Blvd., Richmond, California.

● A 12-page brochure describing metallurgical and materials engineering as an exciting, rewarding profession may be obtained from the American Society for Metals, Metals Park, Ohio.

● The Model J Chloride Ion Analyzer, its description, operation, and specifications, is described in a new *Bulletin 4022-B* released by the Technical Information Department, Scientific and Process Instruments Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, California.

● A new 16-page issue of *What's New for the Laboratory*, 49th in the series, has been announced by the Scientific Glass Apparatus Co., Inc., Bloomfield, New Jersey. Approximately forty new units are illustrated and described.

● The following may be requested from Ultra-Violet Products, Inc., 5114 Walnut Grove Ave., San Gabriel, California. Newly revised brochure, *Bulletin No. 134*, which illustrates the value of short-wave and long-wave ultraviolet for laboratory analysis and inspection; and newly revised brochure, *Bulletin No. 126*, that describes compact table-top ultraviolet darkroom which provides maximum darkness for brilliant fluorescence regardless of outside light.

● The Society for Applied Spectroscopy offers *Bibliography on Analytical Flame Spectroscopy* by R. Mavrodineau at $15 each for Volumes I and II or $25 per set. Write P.O. Box 7164, Baltimore 18, Maryland.

● For complete information and prices on the entire line of columns and accessory items available from F & M, request the catalogue which lists over 180 different liquid phases, adsorbents, and column supports. In addition, 9 standard column packings, information on packed columns, and how to order columns made to your specifications is included. Write F & M Scientific Corp., Avondale, Pennsylvania

● A new 8-page technical brochure is available from the Jarrell-Ash Co., 26 Farwell St., Newtonville, Massachusetts, regarding the firm's Model 23-500 recording microphotometer. Photographs, drawings, and technical data explain

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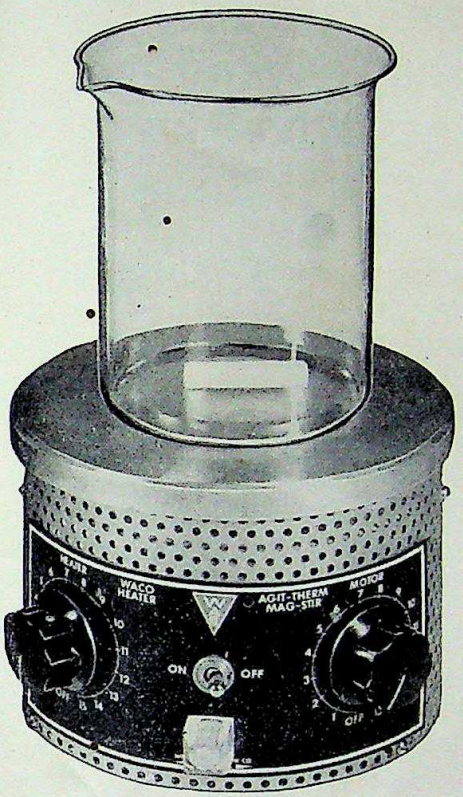

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the operating features and technical specifications of the Model 23-500, as well as an optional digital read-out system and a photoelectric setting device.

● New polycarbonate centrifuge ware combining window-clear transparency with high impact and tensile strength is announced by The Nalge Co., Inc., 75 Panorama Creek Dr., Rochester 25, New York. Also available is a six-page brochure of new products including a plastic separatory funnel.

● A new comprehensive 8-page catalogue *No. 27234-D* of conductivity equipment designed for use by growers, universities, and research stations for soil and water measurements has been issued by Industrial Instruments, 89 Commerce Rd., Cedar Grove, New Jersey.

New Chemicals

◇ Calbiochem, P.O. Box 54282, Terminal Annex, Los Angeles 54, California, offers *Biologics* No. 32 that describes a number of "Do-it-yourself coenzymes."

◇ The American Petroleum Institute announced recently the availability of two new standard hydrocarbon samples, bringing to 300 the number of such samples issued by the API. The new samples are 1, trans-2, cis-3, trans-4-tetramethylcyclopentane and 1-methyl-3-ethyl-5-tert-butylbenzene. A full list of all available standard hydrocarbons may be obtained by writing to Carnegie Institute of Technology, Attention: Beveridge J. Mair, Petroleum Research Laboratory, Pittsburgh 13, Pennsylvania.

◇ Newly available from Applied Science Laboratories, Inc., State College, Pennsylvania, are the following pure radiochemicals: Cholesteryl linoleate, cholesteryl stearate, cholesteryl oleate, cholesteryl linoleate, tripalmitin, tristearin, triolein and trilinolein. All of these are of the 1-C-14 tagged variety.

Miscellany

★ A fast and easy way to look up element information has been developed by The Viking Co., 113 S. Edgemont, Los Angeles 4, California. Viking's new Element Dial lists at $1.00 and gives complete information on 50 important elements from aluminum to zinc, and is specifically designed for chemistry students, chemical engineers, research directors, metallurgists, atomic engineers, and chemists.

★ A Symposium on the Ellipsometer and its use in the Measurement of Surfaces and Thin Films, will be held by the National Bureau of Standards, Washington 25, D. C., September 5–6, 1963. Contact Elio Passaglia, NBS, Chairman for further information.

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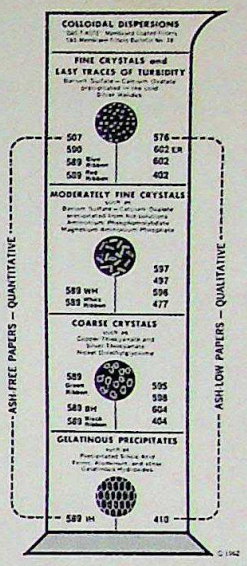

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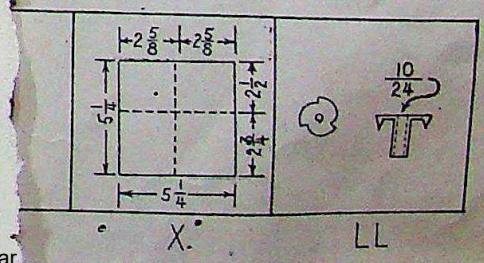

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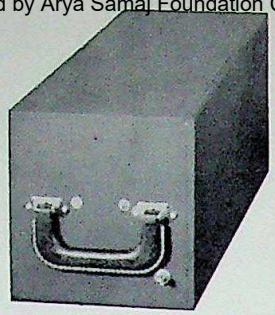

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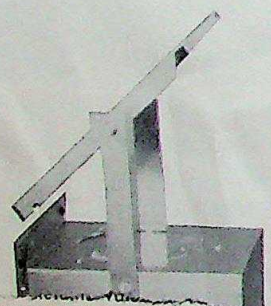

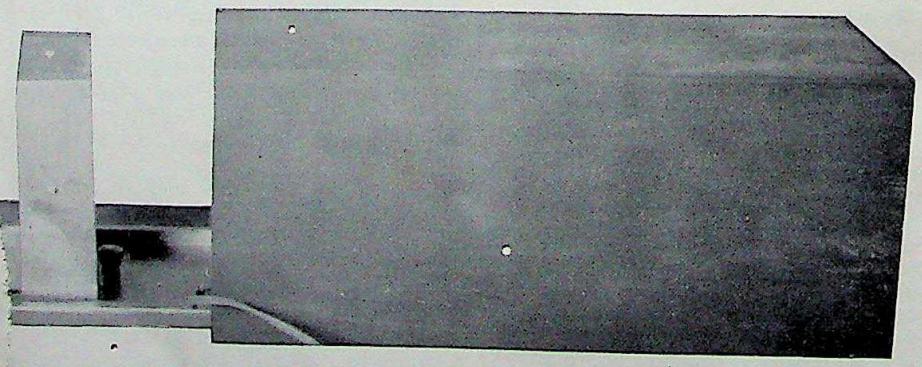

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Princeton University

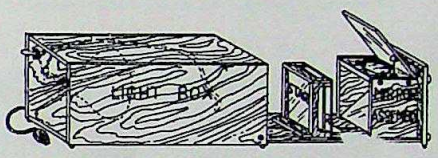
SPECIAL DEVICE SD-16 AN INEXPENSIVE OVERHEAD PROJECTOR

The TOPS projector described in this article was developed at Princeton by *Isjrin Noerdin*, Bandung Technological Institute, Bandung, Indonesia, *Denver Ulery*, Ingraham High School, Seattle, Washington, *LeRoy Hornbeck*, University of Washington, Seattle, Washington, *Robert Barnard*, Montana State College, Bozeman, Montana, and *Albert Surina* and *Hubert N. Alyea* of Princeton University. Drawings by *Lillias Brescia* of Manahawkin, New Jersey.

The following inexpensive ($15) make-it-yourself projector brings TOPS projection-of-experiments within the budget of *every* teacher. Novelties include (*a*) use of an ordinary 150-W, 110-v indoor spotlight ($1) having a 2000-hr life, and (*b*) focusing achieved by moving the stage instead of the lens. Optically it is excellent, the image being as clear as with an expensive projector. However because of the low wattage of the projection lamp it is preferable to have a nearly darkened room and a relatively small projection image, say 3 × 3 ft. Assembly time 15 hours.

Assembling the Light Box: (*a*) Cut parts and drill all holes excepting the $^{13}/_{64}$-in. hole in the base (*A*). (*b*) Mount the light socket (*S*), switch (*T*), and handle (*Y*) on the end (*C*), noting that the socket does not come in the center but slightly above center. (*c*) Wire the socket and switch in series. (*d*) Nail and glue the side pieces (*B*) to the end. Nail and glue the top and the base pieces (*A*) in place. (*e*) Nail the small rubber feet (*DD*) in place. (*f*) Bore $^{3}/_{32}$ holes for the stopscrews, but do not insert the stop-screws or bore the $^{13}/_{64}$-in. hole near the open end until further instructions.

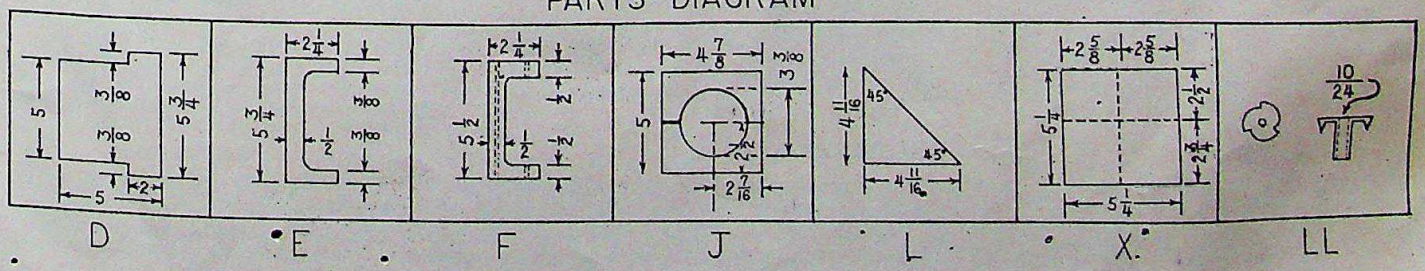
Assembling the Stage: (*a*) Cut all parts and groove sides (*F*) and glue them to base (*D*). (*b*) Slip the Fresnel lens (note in Parts Diagram this lens, *X*, is cut square but the center of the lens is above not at the center of the square) and glass (*O*) into grooves in the side-pieces but do not glue. (*c*) Glue on top $^{1}/_{4}$-in. plywood piece (*E*). (*d*) Cover the $5^{3}/_{4}$ × 2-in. portion of *D* with double-sticky tape. (*e*) Work 1 ml aquarium cement to putty-consistency. Run a bead of it along a long edge of glass *M*. (*f*) Press *M* firmly against and flush with the edge of glass *N*, assuring uniform thickness of cement. Scrape off excess cement. (*g*) Now bring *N* + *M* to stage. Hold *N* against the two sides (*F*) and slide it down, bringing *M* into contact with the double-sticky tape. Press *M* firmly onto the tape. (*h*) Fasten *N* to *F* by using $3^{1}/_{4}$-in. lengths of $^{1}/_{2}$-in. adhesive tape on each side, running along the outer edge of the top board, then down



along the edge of the glass plate about an inch. (*i*) The flat-headed screws (*AA*), which will be inserted after the Mirror Assembly is constructed, hold the stage to the base of the Mirror Assembly securely but free to slide smoothly on the base (*G*). They should be cut off at $^{5}/_{8}$-in. length so as not to extend through plywood stage (*D*), and should be anchored with Elmer's Glue so they will not jolt loose.

Assembling the Mirror Assembly: (*a*) Cut all parts, bore all holes excepting the tee nut hole in the base board (*G*). The slot in base *G* is $12^{1}/_{4}$ × $^{5}/_{32}$ inches. The lens mount (*J*) has a slit cut to facilitate cutting the large hole. (*b*) Hammer the tee nut into place on the lens mount (*J*). (*c*) Screw three soldering lugs on one side of the wooden lens mount. Insert one lens (*R*), flat side against the lugs, bending the lugs down slightly to hold the lens securely. (*d*) Cement a $^{5}/_{16}$-in. (or thinner) cardboard (*NN*) in the opening, pressing it firmly and evenly against the lens so that when the second lens is inserted, this cardboard spacer will hold the two glass lenses evenly spaced with their plane surface parallel. (*e*) Insert second lens (*R*) and fasten it firmly against the cardboard spacer with the remaining three lugs, bending them against the lens also. (*f*) Nail and cement the end (*H*) to the base (*G*), noting that the two are not flush but that there should be a $^{1}/_{4}$-in. projection of the end below the base. (*g*) Nail and cement the sides (*I*) to the base (*G*) and end (*H*), using the bottom mirror (*Q*) as a spacer. (*h*) Cement the triangular pieces of plywood (*L*) to *G* and *H*. (*i*) Slide the assembly into the Light Box; stand it on end with carrying handle up so as to make the Light Box flush with the back of the Mirror Assembly. Holding the two units in this position, bore a $^{13}/_{64}$-in. hole through the Light Box and base board (*G*) of the Mirror Assembly simultaneously. (*j*) Remove Mirror Assembly and hammer the tee nut (*LL*) into the mirror side of the base (*G*) through the hole just bored. (*k*) Put double sticky tape along the edges of the triangles and press the lower mirror firmly into position. (*l*) With four screws (*AA*) fasten the lens mount above the mirror. (*m*) Glue the sponge rubber weather stripping into position. (*n*) Hinge the upper mirror in position with adhesive tape. (*o*) Cover the back of the mirror and the hinge with Contact paper (*MM*) or other protective backing. (*p*) Screw the four large rubber feet (*CC*) on the end (*H*) of the Mirror Assembly. (*q*) Nail and glue the wooden stop (*K*) in place on the base (*G*). (*r*) Attach the stage using screws *AA*. (*s*) Slide the Mirror Assembly into the Light Box and into it screw the two stopscrews (*FF*). (*t*) *BB* is used to support the mirror and also to secure the Mirror Assembly to the Light Box.

PARTS DIAGRAM



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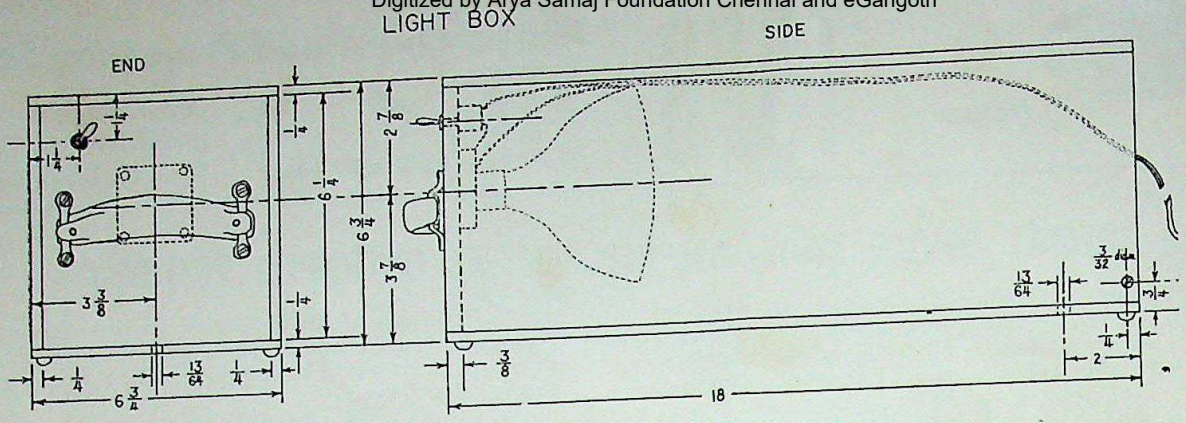

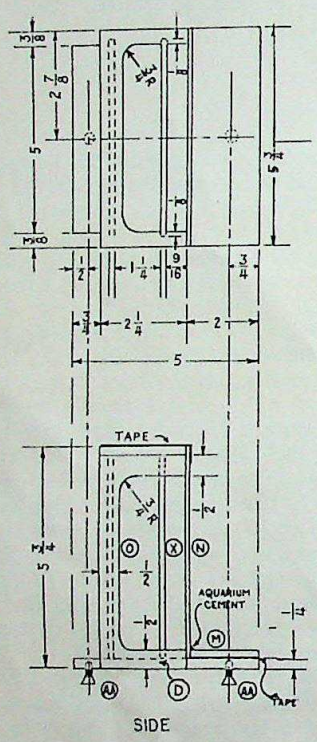

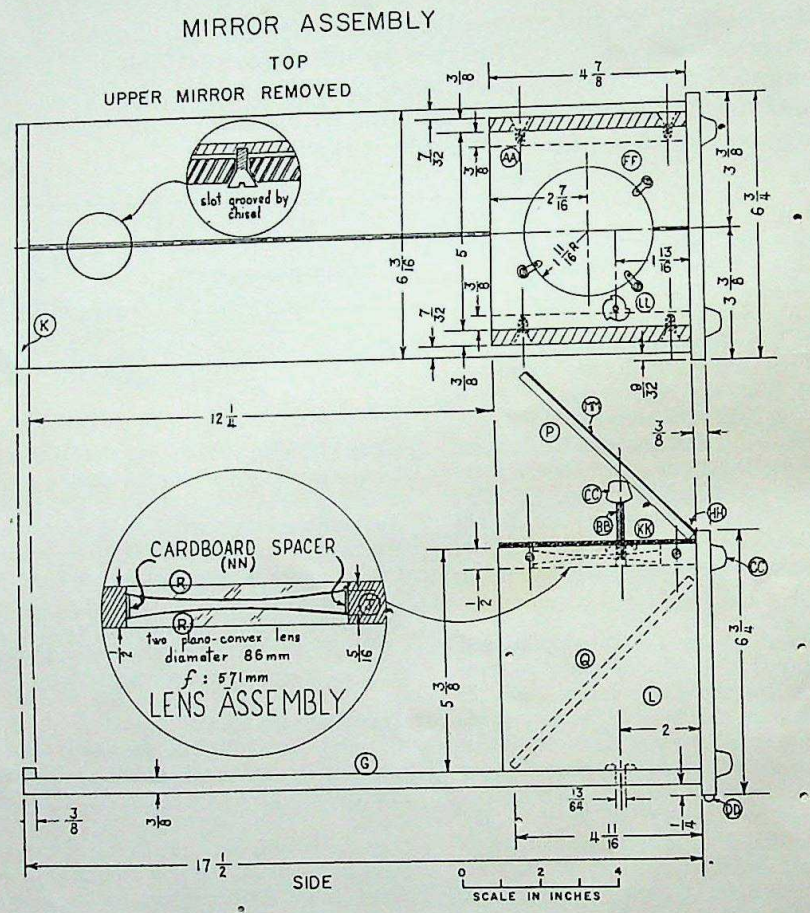

PARTS LIST

PLYWOOD

Light Box

A—top, base (2×) 18 × $6^3/_4$ × $^1/_4$ in.
B—sides (2×) 18 × $6^1/_4$ × $^1/_4$ in.
C—end, $6^1/_4$ × $6^1/_4$ × $^3/_8$ in.

Stage

D—base, $5^3/_4$ × 5 × $^1/_4$ in.
E—top, $5^3/_4$ × $2^1/_4$ × $^1/_4$ in.
F—sides (2×) $5^1/_2$ × $2^1/_4$ × $^3/_8$ in.

Mirror Assembly

G—base, $17^1/_2$ × $6^3/_{16}$ × $^3/_8$ in.
H—end, $6^3/_4$ × $6^3/_4$ × $^3/_8$ in.
I—sides (2×) $5^3/_8$ × $4^7/_8$ × $^3/_8$ in.
J—lens mounting, 5 × $4^7/_8$ × $^1/_2$ in.
K—stop, $6^3/_{16}$ × $^1/_2$ × $^1/_4$ in.
L—triangle mirror supports (2×), $4^{11}/_{16}$ × $4^{11}/_{16}$ × $^3/_8$ in.

GLASS (best grade, polished edges)

M—$5^3/_4$ × $1^7/_8$ in. (double strength)
N—$5^3/_4$ × $5^1/_2$ in. (single strength)
O—$5^1/_4$ × $5^1/_4$ in. (single strength)
P—$6^1/_2$ × 6 in. (plate mirror)
Q—$6^1/_2$ × 5 in. (plate mirror)
*R—(2×) plano convex lenses 86 mm dia., 571 mm focal length

ELECTRICAL

S—porcelain socket
T—SPST switch
U—8-ft. extension cord, 2 wire
V—male plug
W—GE clear R-40, 150-W, 110-v spotlight; or GE PAR 38, 150-W, 110-v floodlight, or single element automobile headlights

MISCELLANEOUS

*X—Fresnel plastic lens 10 in. dia. $8^1/_4$ in. focal length. Note it is cut off-center, see Figure, Parts Diagram.
Y—carrying handle
Z—50 wire brads $^3/_4$ in. long, No. 19
AA—12 brass flathead screws, $^3/_4$ in. long, No. 6
BB—3 in. machine screw, $^{10}/_{24}$ thread
CC—5 large rubber feet
DD—6 small rubber feet
EE—6 solder lugs to hold lenses
FF—8 pan head metal screws $^3/_8$ in. long, No. 6
GG—Elmer's Glue
HH—Adhesive tape 1-in. and $^1/_2$-in. wide.
II—20 in. Dubl-Stik tape, Kleen-Stik Products, Chicago 31, Ill.
JJ—aquarium cement
KK—10 × $^3/_8$ × $^3/_{16}$ in. sponge rubber weather stripping
LL—2 tee-nuts, $^{10}/_{24}$ threads (see Figure)
MM—8 × 8 in. Contact paper
NN—cardboard about 11 × $^5/_{16}$ × $^1/_{32}$ in.

*From Edmund Scientific Co., Barrington, N. J. ($9).

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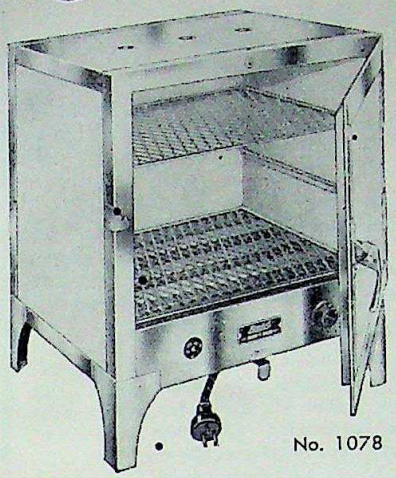

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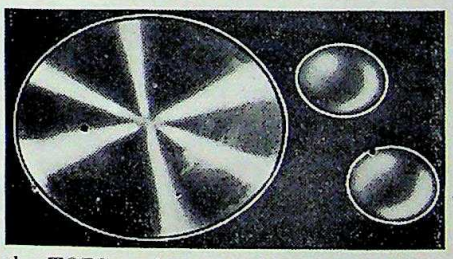

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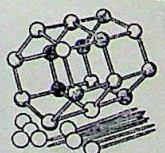

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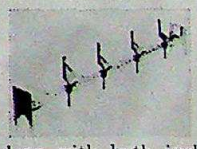

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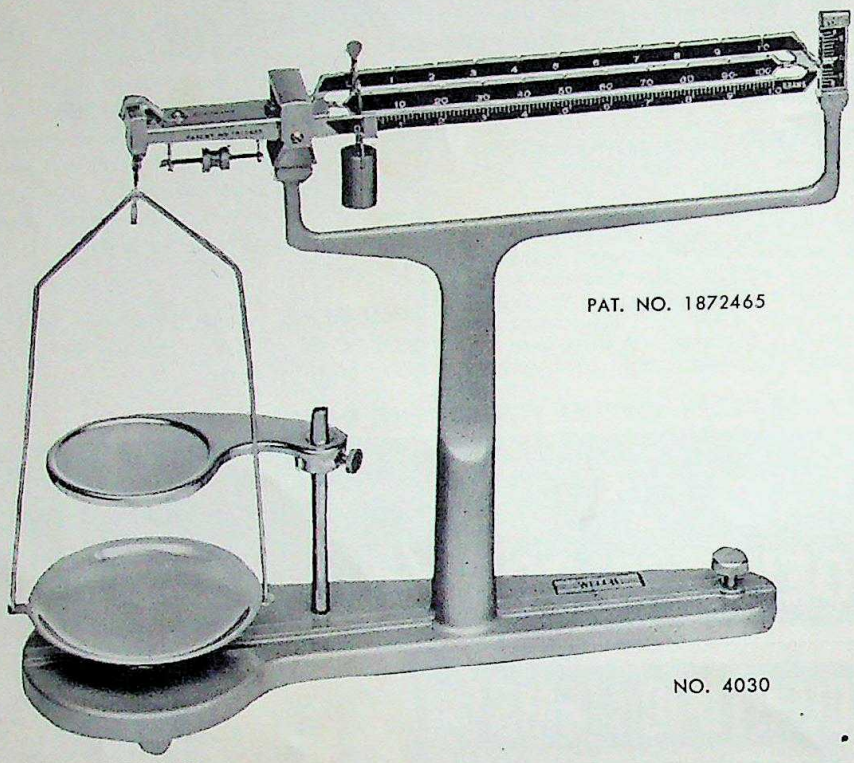

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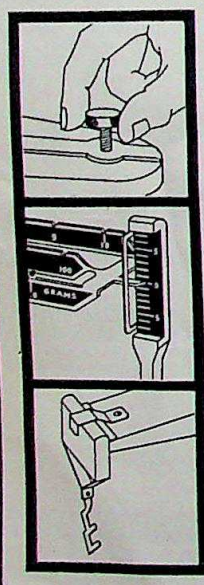

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Chem Ed

EDITORIALLY SPEAKING

Future historians of American education, certainly those concerned with scientific education, will mark the fall of 1963 as a significant date. This is the time for publication in final form of the materials prepared for teaching high school chemistry by the two NSF-financed projects, CBA and CHEMS.

So much has been written about these programs that few chemists need to be told what the letters stand for. CBA, the Chemical Bond Approach Project, began as a hopeful summary of discussions held between high school and college teachers in the summer of 1957 at Reed College. At a similar conference a year later, enthusiastic reports of success by those teachers who were brave enough to try something completely new convinced the planners that a large scale project would be worth the effort. NSF support began significantly in the summer of 1959 with a grant for the preparation of materials and their trial by fire in high schools the following year. Three summer institutes were held in 1960 and about 50 schools taught the program during the succeeding school year. Since that time, the intensity and scope of the effort have increased each year. Summer institutes have trained more teachers who in turn have brought back the results of their experience in the classroom. Now after this feedback from over 300 teachers working with over 20,000 students, the text materials have emerged from three trial editions into a form suitable for book publication.

CHEMS, Chemical Education Materials Study Project, has a parallel story. It began similarly with the conviction that a completely new approach to high school chemistry could be taken. Organization and planning were financed from the beginning in 1960 by the NSF. Here, too, high school and college teachers worked together, institutes were held and constant feedback was established. Similarly, the text materials have gone through repeated trial editions, scrubbed clean by their encounter with over 40,000 students.

During recent months the materials thus developed have been receiving dedicated but not-so-tender treatment from the blue pencils of experienced book editors. This puts the final mark of excellence on the product of prodigous effort by many of the best chemist-teachers in the country. W. H. Freeman and Company in San Francisco plans an initial press run of about 100,000 copies each of the CHEMS text, "Chemistry—An Experimental Science," and the laboratory manual with the same title. McGraw-Hill in New York has similar plans for its issue of the CBA textbook, "Chemical Systems," and the accompanying laboratory book, "Investigating Chemical Systems."

There is an additional similarity in these two programs. This is the existence of carefully prepared teachers' guides and other aids to convince the less venturesome or more overworked that it is practical for him to try something new. These helps range all the way from answers to what is practically a "trouble shooting" guide that anticipates what will happen if a student does not follow experimental directions. CHEMS has further enriched all teaching of introductory chemistry in both high school and college by preparing a series of remarkably high quality films. These are carefully planned by experts who know both their subject and how to present it. The producers, photographers, and film editors are equally expert so that five of the films already produced have won professional awards.

Every school administrator should at least know of the existence of these programs. This is a service to education which readers of these pages can perform. The headquarters for CBA is at Earlham College, Richmond, Indiana. McGraw-Hill's address is 330 W. 42nd Street, New York 36. CHEMS headquarters is at the Lawrence Hall of Science on the Berkeley campus of the University of California. The Freeman Company is at 600 Market Street, San Francisco 4. The CHEMS films are distributed by Modern Learning Aids, 3 E. 54th Street, New York 22.

The "disguished" in last month's comments was a disgushting triumph by the plogglies that infest every printing operation. It was not an attempt by the Editor to invent a new thirty-nine cent word.

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Richard G. Layton and
Edward M. Eyring
University of Utah
Salt Lake City

Laser Experiments in Undergraduate Physical Chemistry Laboratory

Since they were first envisaged by Schawlow and Townes in 1958 (*1*), solid state optical masers (lasers) have become comparatively inexpensive so that their use is now practicable in an undergraduate physical chemistry laboratory to illustrate several fundamental chemical concepts. We have borrowed a laser from our Physics Department and have had a group of juniors in chemistry and chemical engineering perform two experiments that permit a wide range of instructive calculations.

The necessary components of an improved laser are shown schematically in Figure 1. Three oil-filled 100 microfarad capacitors wired in parallel are charged to 3000 v by a dc power supply. Using a Tessla coil (vacuum leak detector) as a trigger, the capacitor bank is then discharged through five 150 watt xenon discharge tubes (EG & G FX-100) all of which are in contact with and parallel to a $^3/_8$-in. diameter × $3^1/_4$-in. long pink ruby rod, i.e., corundum (Al_2O_3), doped with Cr_2O_3 to the extent of 0.05% by weight. An additional inductance (*2*) would have limited the peak current to

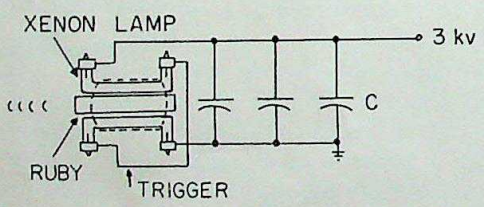


Figure 1. Schematic diagram of an improvised ruby optical maser for use on an undergraduate physical chemistry laboratory. The dashed lines about the xenon lamp-ruby rod assembly represent aluminum foil. Only two of the five xenon lamps used are actually shown here. The trigger actually makes contact with the aluminum foil and not the end of the tube.

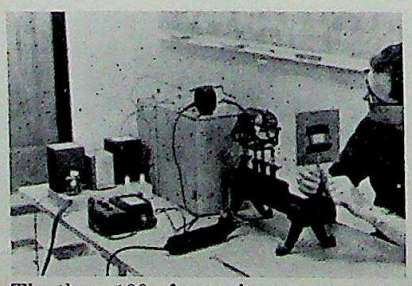
the discharge tubes and thus prolonged tube life. A piece of aluminum foil is wrapped around the laser rod-xenon tube assembly so that most of the flash of white light from the xenon lamps is dissipated in the ruby rod. This grouping of cylindrical xenon tubes is less familiar than either the helical flash tube or the arrangement in which one cylindrical discharge tube and the laser rod are placed at the two foci of a specularly reflecting cylindrical ellipse (*3*). The ~100 microsecond (*2*) flash of "green" light from the xenon tubes "pumps" the bulk of the Cr^{+3} ions out of the ground $^4A_2$ electronic state and into a band of excited electronic states such as the $^4T_1$ and $^4T_2$ states (*4*). This is not the familiar spectroscopic notation of gaseous monatomic ions but rather that appropriate to the description of the states of an ion in a crystal field (*5*). By either radiative or radiationless transitions many of the excited Cr^{+3} ions drop back down to the metastable ^2E state from which a radiative transition to the ground $^4A_2$ state is comparatively improbable. Rubies have long been prized for the red fluorescence produced by the $^2E \rightarrow {}^4A_2$ transition. If the pumping to excited states and subsequent reversion of a considerable number of Cr^{+3} ions to the ^2E state has occurred rapidly enough, the population of the ^2E state is greater than that of the ground $^4A_2$ state and a "population inversion" is said to exist. This is a colorful way of saying that the Boltzmann statistical distribution

$$N_1/N_0 = \exp[-(\epsilon_1 - \epsilon_0)/kT]$$

no longer applies to the relative populations of these two electronic states of the Cr^{+3} ions in the laser rod. If a population inversion exists and one of the ^2E Cr^{+3} ions makes the "forbidden" transition to the $^4A_2$ state, a red photon is emitted that will stimulate emission at the same wavelength by other ^2E Cr^{+3} ions and the process snowballs into a cascade of $^2E \rightarrow {}^4A_2$ transitions. It is the stimulated emission of light in contrast to spontaneous emission that distinguishes laser action from ordinary fluorescence. The two plane parallel ends of the laser rod are mirrored with a dielectric (metal oxide) coating. One mirror is fully reflecting to red light, the other is 99.7% reflecting. It is only the light which repeatedly traverses the rod that stays in long enough to effect much stimulation. Since stimulated light travels

NOTE ADDED IN PROOF: Since the above was written we have changed the laser pumping system. The present system (see cover) utilizes an EGG FX-42 linear flashtube parallel to the axis of a silvered, circular cylindrical cavity. The ruby is mounted symmetrically opposite the flashtube. This arrangement is slightly less efficient than an elliptical cavity, but substantially more effective than our previous pumping scheme. It also is less expensive than our former system since only one flashtube is required, and the 3-in. diameter glass tubing from which the cavity is fabricated is just scrap.

The Cover



Co-author R. G. Layton is shown adjusting the grating in front of the ruby rod. This is involved in the simple wavelength measurement as described in the paper. The three 100-μf capacitors, power supply, and other components are easily identified.

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in the same direction as the stimulating light. The only strongly amplified light is that moving parallel to the laser axis and perpendicular to the dielectric mirrors. The typical red flash of light emitted through the partially transmitting end of the laser has a duration of about a millisecond and consists of many high energy spikes separated by short intervals of low intensity. The spikes in the output probably result from the stimulated emission proceeding faster than optical pumping with a consequent depletion of Cr^{+3} ions in the metastable ^2E state (*6*); the red light abruptly weakens until the xenon flash can restore the population inversion. The remarkable coherence of the laser beam, other methods of pumping optical masers, non-solid state optical masers, and even masers in which a population inversion is not required (*7*) are all interesting topics that do not bear directly on this experiment.

Our students were required to measure the wavelength of the emitted red light and the energy of a single $\sim 10^{-3}$ sec pulse. Students were first warned of two hazards associated with the operation of this laser: The capacitor bank is dangerous even when "discharged" since unless carefully shorted the bank carries a residual voltage of $\sim$300 v. Anyone who insists on looking end-on at the laser when it is fired will experience permanent damage to the retina of his eye.

An approximate measurment of the wavelength can be accomplished very rapidly. Since the ruby laser emits a well collimated beam of light, a ruled diffraction grating (blazed for second order) and a meter stick are the only additional equipment required. On a wall approximately 10 ft in front of the laser we mark the position at which the red dot projected by the laser is observed. The diffraction grating is then placed immediately in front of the emitting end of the laser, and the location of the more diffuse, diffracted red dot is also marked on the wall. With the measured distances shown in Figure 2 from a typical experiment and the

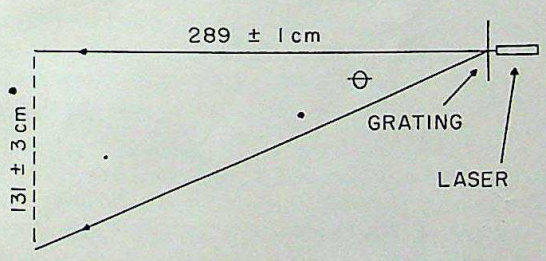

Figure 2. Arrangement for determining the wavelength of light emitted by a ruby laser using a diffraction grating blazed for second order.

Bragg equation $n\lambda = 2d \sin \theta$ which is appropriate for normal incidence (for our particular grating $n = 2$ and $d = 1$ mm/603 lines), we can rapidly calculate the approximate wavelength $\lambda = 6880 \pm 200$ Å. There are actually two red fluorescence lines in ruby arising from a 29^{-1} cm splitting of the metastable ^2E level of Cr^{+3}. This splitting is caused by the non-cubic field of the skewed octahedron of oxygens surrounding the Cr^{+3} ion (*8, 9*). At 60°C the maxima in the two emitted bands occur at about 6931 and 6945 Å respectively and these maxima shift to 6920 and 6934 Å with considerable reduction in band width as the temperature is dropped to 77°K (*8*). Thus our measured wavelength is not seriously in error and is actually quite satisfactory for the subsequent student calculations.

To determine the energy of a single pulse from our ruby laser we have simplified an elegant technique reported by Li and Sims (*10*). The pulse of red light is dissipated in the brass cone (35% Zn, 62% Cu, 3% Pb) shown schematically in Figure 3. The flash of light from the xenon lamps is screened off from the brass cone by an aluminum foil shield that is perforated at only one point to permit passage of the laser beam. The inner surface of the brass cone is coated with carbon black to maximize light absorption. A thermistor (Sargent 81620) fitted in the end of the cone with a speck of wax constitutes one arm of a Wheatstone bridge (Sargent Thermistor Bridge 81600) across which a rather insensitive galvanometer (Weston 440) has been wired. The bridge is balanced, the setting of the variable resistor in the bridge is recorded, and the laser is triggered. The bridge is then rapidly balanced a half dozen times during

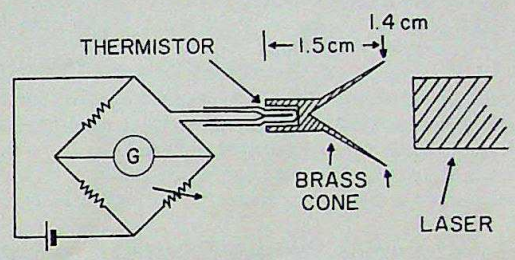

Figure 3. Schematic of the brass cone, thermistor, and Wheatstone bridge required to measure the energy of a single ruby laser pulse.

the next 90 sec with times and resistor settings being recorded by a second student. Once the thermistor-bridge arrangement has been calibrated using a constant temperature bath and Beckmann thermometer to cover five centigrade degrees above room temperature, the rise in temperature ΔT of the brass cone can be extrapolated back to time zero as in Figure 4. For $\Delta V = (3000\text{–}300)v$ and $C = 3 \times 10^{-3} f$, we repeatedly measured $\Delta T = 3.12 \pm 0.16$°C. The amount of energy dissipated in the lampblack and thermistor tip can be neglected because of their much smaller combined mass than that of the brass cone. The 0.006 g of wax ($C_p \approx$ 0.69 cal/g °C) could not be neglected and is included along with the brass cone ($m = 0.639$ g, $C_p \approx 0.09$ cal/g °C) in the following equation for the energy per pulse of this laser:

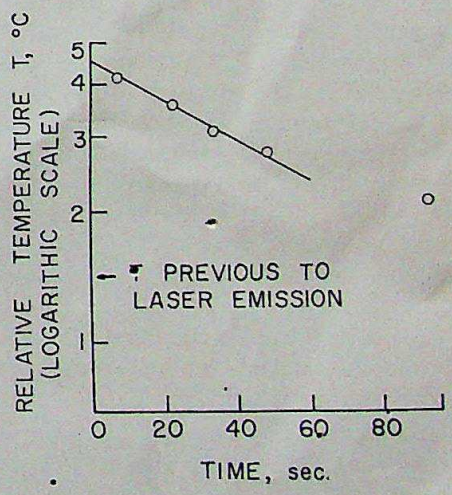

Figure 4. Extrapolation of the temperature of the brass cone back to time zero.

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$$\Delta E = 4.19 \text{ (joule/cal)} \; \Delta T \sum_i m_i C_{pi} \cong 0.81 \text{ joule}$$

This value is quite plausible when compared with the energy delivered with less pumping power from a ruby of similar size (*11*). With no air currents in the laboratory our energy measurement is not seriously compromised by convection heat loss from the brass cone, and the inconvenience of placing the cone in an evacuated cell with a plate glass window is not justified.

Once values of λ and ΔE had been determined the following problems were considered:

(1) Assuming a concentration of 0.05% Cr_2O_3, how many Cr^{+3} ions are present in the ruby rod?
(2) From the experimental data calculate the number of $^2E \rightarrow {}^4A_2$ transitions required to deliver the energy of the observed pulse.
(3) At room temperature what are the relative populations of the ground and metastable states of the Cr^{+3} ions?
(4) Under the excited condition, what are the relative populations of the ^2E and $^4A_2$ levels? To what Boltzmann temperature does this correspond?
(5) If in the course of a single millisecond pulse all the Cr^{+3} ions experienced a single $^2E \rightarrow {}^4A_2$ transition, what would be the output power of the ruby? How much energy would have been stored in the rod per unit volume?
(6) What is the approximate temperature gradient at the outside surface of the brass cone 8 sec after firing the laser?

An exact answer to the fourth question is impossible from the data taken since some of the Cr^{+3} ions are in neither state under the excited conditions. However, since a population inversion must exist for laser action to occur, the Boltzmann temperature is clearly negative. The last question can be answered from the kinetic theory result for the thermal conductivity of air.

There are a sufficient number of potential applications of optical masers in communications and warfare to excite the interest of most undergraduates. There are also a number of likely uses in future chemical research that would warrant the inclusion of laser experiments in the undergraduate curriculum even if they did not illustrate the diversity of fundamental concepts mentioned above. For instance, Townes (*12*) has suggested the use of a ruby laser as the light source for very high resolution Raman spectroscopy, and Raman spectra have since been obtained using a laser (*13*). Optical masers should also prove useful in perturbation method studies (*14*) of very rapid chemical reactions (*15*). Optical masers that emit short high energy pulses at wavelengths further into the blue than a ruby rod does will be powerful monochromatic light sources for flash photolysis experiments. A high power optical maser could also be used as the source of ~10 joules of energy to heat a 0.5 ml aqueous solution by 5°C in a microsecond or perhap even 10 nanoseconds in temperature-jump kinetic studies of the type developed by Czerlinski and Eigen (*16, 17*). Cutting the laser pulse length to a microsecond without drastically decreasing the total energy output has already been accomplished by *Q*-spoiling (*18, 19*). In essence, a Kerr cell or notched turbine blade is used to hide the mirror at one end of the laser rod from the excited Cr^{+3} ions for all but the very brief interval during which stimulated emission is desired. If the laser rod is thought of as an organ pipe, spoiling the *Q* of the cavity simply means that the length of the pipe is deliberately adjusted almost all the time to have the wrong length to produce the expected melodic tone. If a ruby rod were used as a temperature-jump heating element, a blue substance such as copper sulfate would have to be present in the sample solution to absorb the red laser beam as electronic energy that would be rapidly degraded by radiationless transitions to vibrational (thermal) energy of all species in solution. A more attractive laser material for this particular application would be neodymium-doped calcium tungstate or glass that delivers light at 1.06 microns (near infrared). This wavelength intercepts a shoulder of one of the vibrational absorption bands in water and would therefore permit direct, uniform heating of an aqueous solution by repeated passes (during less than a microsecond) of the laser pulse through the mirrored sample cell. Fast changes in concentration of the sample species following the temperature perturbation could be followed using standard spectrophotometric techniques (*16*) and a second less exotic light source. Lengyl's new monograph should be consulted for other interesting relationships between lasers and chemistry (*20*).

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Literature Cited

(1) Schawlow, A. L., and Townes, C. H., *Phys. Rev.*, **112**, 1940–1959 (1958).
(2) Edgerton, H. E., "Advances in Quantum Electronics," ed. Singer, J. R., Columbia University Press, New York, 1961, pp. 276–287.
(3) Svelto, O., *Applied Optics*, **1**, 745–751 (1962).
(4) Sugano, S., *Applied Optics*, **1**, 295–301 (1962).
(5) Prather, J. L., "Atomic Energy Levels in Crystals," National Bureau of Standards Monograph 19, Washington, D. C., 1961.
(6) Siegman, A. E., Applied Optics, **1**, 744 (1962).
(7) Shimoda, K., Applied Optics, **1**, 303 (1962).
(8) Schalow, A. L., "Advances in Quantum Electronics," ed. Singer, J. R., Columbia University Press, New York, 1961, pp. 50–64.
(9) McClure, D. S., *J. Chem. Phys.*, **36**, 2757–2779 (1962).
(10) Li, T., and Sims, S. D., *Applied Optics*, **1**, 325–328 (1962).
(11) Sage, S. S., *Applied Optics*, **1**, 173–179 (1962).
(12) Townes, C. H., "Advances in Quantum Electronics," ed. Singer, J. R., Columbia University Press, New York, 1961, pp. 8–9.
(13) Porto, S. P. S., and Wood, D. L., *J. Optical Soc. Amer.*, **52**, 251–252 (1962).
(14) Eigen, M., and Johnson, J. S., "Annual Review of Physical Chemistry," ed. Eyring, H., Annual Reviews, Inc., Palo Alto, Calif., 1960, pp. 314–317.
(15) Frost, A. A., and Pearson, R. G., "Kinetics and Mechanism," 2nd ed., John Wiley and Sons, Inc., New York, 1961, Chap. 11.
(16) Czerlinski, G., and Eigen, M., *Z. Elektrochem.*, **63**, 652–661 (1959).
(17) Eyring, H., and Eyring, E. M., "Modern Chemical Kinetics," Reinhold Publishing Corp., New York, 1963, Chap. 6.
(18) Marshall, F. R., Roberts, D. L., and Wuerker, R. F., *Bull. Am. Phys. Soc.*, Series II, **7**, 445 (1962).
(19) Basov, N. G., Zuev, V. S., and Crjukov, P. G., *Applied Optics*, **1**, 767–768 (1962).
(20) Lengel, B. A., "Lasers," John Wiley and Sons, New York, 1962.

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Formation Constants of a Metal-Anionic Ligand System in Dioxane-Water

In a recent paper (*1*) the determination of formation constants of metal-amine systems was described. The determination of formation constants of anionic ligand complexes is of comparable research interest and is also an application of solution equilibrium measurements to modern research problems. The problem of obtaining data is more complicated for anionic ligand complexes than for the amine complexes because both the chelating agent and the metal chelate are often insoluble in water. The calculation method depends on having all the species in one phase so that measurements of the concentration of a single species at each point in a titration allow the calculation of the concentrations of all the species at that point.

In order to achieve the desired solubilities, dioxane-water mixtures are often employed, as first described by Calvin and Wilson (*2*). Use of this mixed solvent, however, accentuates the problem of obtaining true thermodynamic data rather than merely quotients of molarities. The solution to the latter problem was first attempted by Van Uitert (*3*, *4*). He solved the stoichiometric equations at one point for each constant to be determined in the calculation of transition metal ion–β-diketone systems.

Later Block and McIntyre (*5*) solved the problem of true thermodynamic constants for aqueous solutions. They also added an algebraic calculation method, which allows the use of more of the data than does the method of Van Uitert. Their method does away with the necessity of using successive approximations (*6*). The procedure described here combines the methods of Van Uitert and of Block and McIntyre, with subsequent modifications also included.

This procedure is more difficult than the amine procedure (*1*) from an experimental viewpoint because of the necessity of using purified dioxane and from a calculation viewpoint because of the greater importance and variability of the activity coefficients.

The discussion is appropriate for a study of various systems; acetylacetone, benzoylacetone, and dibenzoylmethane are satisfactory ligands. Dipositive transition metal ions or uranyl ion can be used. Copper or nickel ions are most appropriate, although some copper complexes have too great a stability to be handled conveniently.

The Experiment

The apparatus used for the potentiometric titration has been described previously (*1*). A glass electrode designed for high *p*H should be used.

The titrations are performed as previously described (*1*), with the following differences:

A precisely known quantity of metal ion, about 1×10^{-3} moles, and a precisely known quantity of chelating agent, about 4×10^{-3} moles, 75 ml of purified (*3*, *7*) dioxane and 25 ml of distilled water are placed in the titration flask. This solution is titrated with standardized tetramethylammonium hydroxide, also in 75 vol % dioxane (*8*). The volume of base added and the *p*H meter reading at each point are recorded. Measurement of the association constant of the anionic ligand with the proton is performed using the same procedure except for the exclusion of the metal ion.

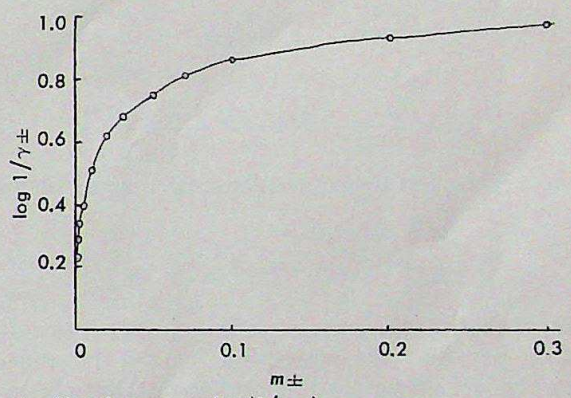

Figure 1. Plot of $m_{\pm}$ versus log $(1/\gamma_{\pm})$.

Calculations

Activity Coefficients. Van Uitert (*3*) has shown that the glass electrode can be calibrated to measure hydrogen ion activity in aqueous dioxane. His factor, $U_H°$, converts the *p*H meter reading, *B*, into activity of hydrogen ion for a range of dioxane-water mixtures up to 75 vol % dioxane. $U_H°$ is dependent on mole fraction dioxane alone, and not on concentrations of the electrolytes in the solutions. By graphical interpolation of the data of Harned and Owen (*9*) on the mean activity coefficients for dioxane-water solutions of HCl, Van Uitert has been able to approximate the activity coefficient at any concentration of electrolyte at any mole fraction dioxane. Instead of recording $1/\gamma_{\pm}$, he reports the quantity log $U_H°$ + log $1/\gamma_{\pm}$ (*10*). A convenient short cut for these calculations is to plot log $1/\gamma_{\pm}$ versus $m_{\pm}$ for a particular mole fraction dioxane. Such a plot is shown in Figure 1. The mean molarity, $m_{\pm}$, is determined for combinations of bi-, univalent and uni-, univalent salt solutions from the equation (*11*):

$$m_{\pm} = \sqrt[3]{4}\, m_{2:1} + m_{1:1} = 1.59\, m_{2:1} + m_{1:1}$$

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Acid Association Constants. For the reaction in which the anionic ligand associates with one proton, the following constants may be defined:[1]

$$H^+ + Ch^- \rightleftarrows HCh \quad (1)$$

$$q_H = \frac{[HCh]}{[H^+][Ch^-]} \quad (2)$$

$$K_H = \frac{(HCh)}{(H^+)(Ch^-)} = q_H \frac{\gamma_{HCh}}{\gamma_{H^+}\gamma_{Ch^-}} \quad (3)$$

Assuming the activity coefficient of a neutral species to be unity, and those of unipositive and uninegative ions to be approximately equal to a mean activity coefficient, $\gamma_\pm$, then

$$K_H = q_H/\gamma_\pm^2 \quad (4)$$

Defining $\bar{n}_H$ as the average number of hydrogen ions bound per Ch^-, one obtains

$$\bar{n}_H = \frac{[HCh]}{[Ch^-] + [HCh]} \quad (5)$$

Substitution from equation (2) leads to

$$\bar{n}_H = \frac{q_H[H^+][Ch^-]}{[Ch^-] + q_H[H^+][Ch^-]} = \frac{q_H[H^+]}{1 + q_H[H^+]} \quad (6)$$

But also

$\bar{n}_H$ = bound hydrogen ion/total ligand

$$\text{bound hydrogen} = \text{total hydrogen} - \text{reacted hydrogen} - \text{dissociated hydrogen}$$

$$= C_{HCh} - C_{OH} - ([H^+] - [OH^-])$$

$$\bar{n}_H = \frac{C_{HCh} - C_{OH} - [H^+] + [OH^-]}{C_{HCh}} \quad (7)$$

The hydrogen ion concentration may be calculated by the equation (*3, 4*)

$$-\log [H^+] = B + \log U_H^\circ - \log \frac{1}{\gamma_\pm} \quad (8)$$

where B is the pH meter reading in the nonaqueous medium, $\log U_H^\circ$ the correction for the difference between the pH meter reading and the activity of hydrogen ion in the nonaqueous solution, and $\log 1/\gamma_\pm$ is the activity coefficient correction to concentrations in the solution.

Substitution of the value for $\log [H^+]$ from equation (8) into equation (7), along with the calculable values of C_x, allows solution for $\bar{n}_H$. Solution of equation (6) for q_H

$$q_H = \bar{n}_H/(1 - \bar{n}_H)[H^+] \quad (9)$$

allows the calculation of this quantity. The thermodynamic constant can be obtained from a revision of equation (4).

$$\log K_H = \log q_H + 2 \log \frac{1}{\gamma_\pm} \quad (10)$$

Metal Ion Formation Constants. For the reactions

$$M^{2+} \pm Ch^- \overset{1}{=} MCh^+ \quad (11)$$
$$MCh^+ + Ch^- \overset{2}{=} MCh_2$$

there are definable the following constants:

$$q_1 = \frac{[MCh^+]}{[M^{2+}][Ch^-]}; \quad K_1 = q_1 \frac{\gamma_{MCh^+}}{\gamma_{M^{++}}\gamma_{Ch^-}} = \frac{q_1}{\gamma_\pm^2} \quad (12)$$

$$q_2 = \frac{[MCh_2]}{[MCh^+][Ch^-]}; \quad K_2 = q_2 \frac{\gamma_{MCh_2}}{\gamma_{MCh^+}\gamma_{Ch^-}} = \frac{q_2}{\gamma_\pm^2}$$

using the approximations (*3*)

$$\gamma_{2+} = \gamma_\pm^2 \text{ and } \gamma_{MCh_2} = 1.0$$

and those listed after equation (3). Defining $\bar{n}$ as the average number of ligands bound per metal ion, one obtains

$$\bar{n} = \frac{[MCh^+] + 2[MCh_2]}{[M^{2+}] + [MCh^+] + [MCh_2]} \quad (13)$$

$$= \frac{q_1[M^{2+}][Ch^-] + 2q_1q_2[M^{2+}][Ch^-]^2}{[M^{2+}] + q_1[M^{2+}][Ch^-] + q_1q_2[M^{2+}][Ch^-]^2}$$

$$= \frac{q_1[Ch^-] + 2q_1q_2[Ch^-]^2}{1 + q_1[Ch^-] + q_1q_2[Ch^-]^2} \quad (14)$$

Note that equation (14) is defined in terms of concentrations, and q_1 and q_2 are used as opposed to K_1 and K_2.

The concentration of free chelating agent, $[Ch^-]$, may be determined as follows:

$$\text{bound hydrogen} = [HCh] = C_{HCh} - C_{OH} - [H^+] + [OH^-] \quad (15)$$
$$= q_H[H^+][Ch^-]$$

Hence,

$$[Ch^-] = \frac{C_{HCh} - C_{OH} - [H^+] + [OH^-]}{q_H[H^+]} \quad (16)$$

The q_H needed in equation (16) may be obtained from K_H with the activity coefficient in the metal ion solution. It will be different in general from the value of q_H obtained directly from the association constant titration at $\bar{n}_H = 0.5$.

The quantity $\bar{n}$ may be determined as follows:

$$\bar{n} = \frac{C_{HCh} - [HCh] - [Ch^-]}{C_M} \quad (17)$$

$$= \frac{C_{HCh} - q_H[H^+][Ch^-] - [Ch^-]}{C_M} \quad (18)$$

$$= \frac{C_{HCh} - (q_H[H^+] + 1)[Ch^-]}{C_M} \quad (19)$$

All of the terms of the last equation are obtainable from stoichiometry or from quantities previously calculated.

Using the values of $\bar{n}$ from equation (19) with the corresponding values of $[Ch^-]$ from equation (16), one may solve for the molarity quotients q_1 and q_2 by the method of Block and McIntyre (*5*). (Sample calculations may be found in ref. (*1*).) Calculation of K_1 and K_2 is most easily accomplished by the rearrangement of equation (12) to the form

$$\log K_n = \log q_n + 2 \log \frac{1}{\gamma_\pm} \quad (20)$$

Sample Calculations

Data for the sample calculations were taken from ref. (*3*), pp. 148, 158. The acid dissociation constant calculation is based on the titration of acetylacetone with tetramethylammonium hydroxide; the formation constant calculation is based on the $Ni(ClO_4)_2$–acetylacetone system.

Acid Dissociation Constant. The point chosen has meter reading B = 11.07 when 1.43 ml of 1.202 M

[1] The use of brackets [ ] will represent concentrations; parenthesis ( ) will represent activities. C_X will represent stoichiometric concentrations of X.

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Formation Constants.

V = 100 ml; 75 vol % dioxane
4.00 mmole acetylacetone; 0.975 mmole $Ni(ClO_4)_2$
Titrant — 1.302 M $(CH_3)_4NOH$

	First Point	Second Point
V (ml)	0.25	1.00
V_T (ml)	100.25	101.00
C_M (mmole/ml)	$\frac{0.975}{100.25} = 9.73 \times 10^{-3}$	$\frac{0.975}{101.00} = 9.65 \times 10^{-3}$
C_{HCh} (mmole/ml)	$\frac{4.00}{100.25} = 3.99 \times 10^{-2}$	$\frac{400}{101.00} = 3.96 \times 10^{-2}$
C_{OH} (mmole/ml)	$\frac{(1.302)(0.25)}{(100.25)} = 3.25 \times 10^{-3}$	$\frac{(1.302)(1.00)}{(101.00)} = 1.29 \times 10^{-2}$
B (pH meter reading)	3.25	5.39
$m_\pm$[2] (see footnote 2)	$1.59(C_M - C_{OH}) + 2\,C_{OH}$	$2\,C_M$
	1.68×10^{-2}	1.93×10^{-2}
$\log U_H^0$	1.04	1.04
$\log 1/\gamma_\pm$ (from Fig. 1)	0.59	0.61
$-\log [H^+] = B + \log U_H^\circ - \log 1/\gamma_\pm$	3.70	5.82
$[H^+]$	2.00×10^{-4}	1.51×10^{-6}
$\log q_H = \log K_H - 2 \log 1/\gamma_\pm$	11.62	11.58
q_H	4.17×10^{11}	3.80×10^{11}
$[Ch^-] = C_{HCh} - C_{OH} - \left(\frac{[H^+] + [OH^-]}{q_H[H^+]}\right)$	4.37×10^{-10}	4.65×10^{-8}
$\bar{n} = \frac{C_{HCh} - (q_H[H^+] + 1)\,[Ch^-]}{C_M}$	0.35	1.34

[2] At first point (half-way through first step of reaction)

$$M^{2+} + HCh + Me_4N^+OH^- = MCh^+ + H_2O + Me_4N^+$$

dipositive ion $= C_M - C_{OH}$

unipositive ion $= [Me_4N^+] + [MCh^+] = 2\,[Me_4N^+] - 2\,C_{OH}$

Hence

$$m_\pm = 1.59(C_M - C_{OH}) + 2\,C_{OH}$$

At the second point in the titration (half-way through the second step of the reaction)

$$MCh^+ + HCh + Me_4N^+OH^- = MCh_2 + H_2O + Me_4N^+$$

there is no dipositive ion. The unipositive ion concentration may be calculated at the end of the first step as 2 C_M. As seen by the equation, the second step neither contributes or uses up net positive ions in the titration vessel, replacing MCh^+ with Me_4N^+. Thus the $m_\pm = 2\,C_M$ throughout the remainder of the titration.

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tetramethylammonium hydroxide was added to a solution containing 3.44 mmoles of acetylacetone yielding a total volume of 53.0 ml. Log U_H° = 1.04 for 75 vol % dioxane (Table 1).

$$C_{HCh} = \frac{3.44 \text{ mmoles}}{53.0 \text{ ml}} = 6.49 \times 10^{-2}\,M$$

$$C_{OH} = \frac{1.43 \text{ ml} \times 1.202\,M}{53.0 \text{ ml}} = 3.24 \times 10^{-2}\,M$$

$m_\pm = C_{OH} = 3.24 \times 10^{-2}\,M$

$\log U_H^\circ = 1.04$ for 75 vol % dioxane

$\log 1/\gamma_+ = 0.69$

$-\log [H^+] = 11.07 + 1.04 - 0.69 = 11.42$

$[H^+] = 3.80 \times 10^{-12}$

$\log K_w$ (75% dioxane) = 18.7 approx. (ref. (*9*), p. 662)
$[OH^-]$ negligible

$$\bar{n}_H = \frac{C_{HCh} - C_{OH} - [H^+] + [OH^-]}{C_{HCh}} = 0.50$$

$$q_H = \frac{\bar{n}_H}{(1 - \bar{n}_H)\,[H^+]} = \frac{1}{3.80 \times 10^{-12}} = 2.63 \times 10^{11}$$

$\log q_H = 11.42$

$$\log K_H = \log q_H + 2 \log \frac{1}{\gamma} = 11.42 + 2(0.69) = 12.80$$

Table 1. Data from Figure 1 of Reference 10

$m_\pm$	$\log U_H$	$\log 1\gamma_\pm$
0.000	1.04	..
0.001	0.81	0.23
0.002	0.75	0.29
0.003	0.70	0.34
0.005	0.64	0.40
0.010	0.53	0.51
0.020	0.42	0.62
0.030	0.36	0.68
0.050	0.29	0.75
0.070	0.23	0.81
0.100	0.18	0.86
0.200	0.12	0.92
0.300	0.08	0.96

Calculation of q_1 and q_2 may be done by the method of Block and McIntyre, as demonstrated in (*1*).

$\log K_1 = \log q_1 + 2 \log 1/\gamma_\pm = 9.09 + 2(0.59) = 10.27$
$\log K_2 = \log q_2 + 2 \log 1/\gamma_\pm = 7.07 + 2(0.61) = 8.29$

Acknowledgment

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Literature Cited

(1) Goldberg, D. E., J. Chem. Educ., 39, 328 (1962).
(2) Calvin, M., and Wilson, K. W., *J. Am. Chem. Soc.*, 67, 2003 (1945).
(3) Van Uitert, L. G., Doctoral Dissertation, Pennsylvania State University, 1952.
(4) Van Uitert, L. G., and Haas, C. G., *J. Am. Chem. Soc.*, 75, 451 (1953).
(5) Block, B. P., and McIntyre, G. H., Jr., *J. Am. Chem. Soc.*, 75, 5667 (1953).
(6) Bjerrum, J., "Metal Ammine Formation in Aqueous Solution," P. Haase & Son, Copenhagen, 1941.
(7) Weissberger, A., and Proskauer, E. S., "Organic Solvents," Oxford, 1935, p. 139.
(8) Kido, H., Master's Thesis, Pennsylvania State University, 1959.
(9) Harned, H. S., and Owen, B. B., "The Physical Chemistry of Electrolytic Solutions," Reinhold, New York, 1958, pp. 717–8.
(10) Van Uitert, L. G., and Fernelius, W. C., *J. Am. Chem. Soc.*, 76, 5887 (1954).
(11) Harned, H. S., and Owen, B. B., *op. cit.*, p. 10.

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Some Experiments on the Stoichiometry of Reactions

Volumetric analysis often consists of the application of a stated, unproved reaction; e.g., students are told that permanganate in acid solution reacts as an oxidizing agent according to the following equation:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

and that hydrogen peroxide under similar circumstances is oxidized as follows:

$$H_2O_2 \rightarrow 2H^+ + O_2 + 2e^-$$

It is therefore possible to estimate the concentration of a solution of hydrogen peroxide by titration with standard permanganate solution.

It was deemed important that students themselves, individually, should first establish by experiment what the stoichiometry of such a reaction is, and the experiments described here are an attempt in this direction. One difficulty lay in the choice of suitable systems for investigation. There seemed to be no point in reinvestigating reactions with which students were likely to be familiar, and hence some other, less common, reactions were finally chosen.[1]

The Experiments

The Reaction of Copper Powder with Iron(III) Ammonium Sulfate Solution. About 0.15 g copper powder, weighed accurately, is gently boiled with about 25 ml about 0.2 *M* iron(III) ammonium sulfate solution containing 100 ml concentrated sulfuric acid per liter plus about 10 ml 2.5 *M* sulfuric acid. When all the copper has dissolved (after about 30 min), the flask is removed from the hot plate and cooled. Phosphoric acid–sulfuric acid mixture and a few drops of indicator (e.g., barium diphenylamine sulfonate) are added and the iron(II) produced in the solution is titrated with standard *M*/6 potassium dichromate solution. From the titration result the students are asked to deduce the stoichiometry of the reaction.

$$xCu^\circ + yFe^{3+} \rightarrow yFe^{2+} + ?$$

The calculation is based on the following principles: The dichromate titration gives the amount of iron(II) that has been produced; that is equal to the amount of iron(III) that has reacted with a known weight of copper. By converting the weight of copper taken and the amount of iron(III) that has reacted into gram atoms, the ratio (x/y) is obtained. This is found to be $^1/_2$ and the reaction is therefore:

$$Cu^\circ + 2Fe^{3+} \rightarrow Cu^{2+} + 2Fe^{2+}$$

A consideration of the relevant redox potentials leads to the same conclusions:

	E° (v)
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.76
$Cu^+ + e^- \rightarrow Cu^0$	+0.52
$Cu^{2+} + 2e^- \rightarrow Cu^0$	+0.34
$Cu^{2+} + e^- \rightarrow Cu^+$	+0.15

These figures show:

Copper metal is more easily oxidized to copper(II) than to copper(I) in solution.
If any copper(I) were formed initially, it would very early be oxidized further to copper(II).
Iron(III) is a sufficiently powerful oxidizing agent to bring about any of these changes.

The students' attention may be drawn to the fact that copper does not dissolve in dilute sulfuric acid. This is added to suppress hydrolysis and subsequent oxidation of iron(II).

The Reaction Between Sodium Hypochlorite Solution and Hydrogen Peroxide Solution. Both reagents are

[1] See also State, H. M., J. Chem. Educ., 39, 297 (1962); Zuehlke, R. W., J. Chem. Educ., 39, 354 (1962).

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supplied as approximately $M/20$ solutions which are standardized: sodium hypochlorite, iodometrically; and hydrogen peroxide, against a standard solution of potassium permanganate. Exactly 10 ml of the sodium hypochlorite solution is then added to exactly 25 ml hydrogen peroxide solution and about 50 ml 2.5 M sulfuric acid is added. After allowing 5–10 min for the reaction to go to completion, the excess of hydrogen peroxide is estimated by titration with standard potassium permanganate solution.

From the determined concentration of sodium hypochlorite, the number of moles in 10 ml solution is calculated. The other titration results give the amount, and hence the number of moles, of hydrogen peroxide that have reacted. It is found that the ratio is 1/1 but the stoichiometric equation can still be written in a number of ways, e.g.,

$$(a)\quad NaOCl + H_2O_2 \rightarrow NaCl + H_2O + O_2$$
$$(b)\quad NaOCl + H_2O_2 \rightarrow NaClO_2 + H_2O$$

Since sodium chlorite in dilute solution does not react with permanganate, equation (b) can finally be selected as most likely.

The Reaction of Hydrazinium Chloride Solution and Potassium Iodate Solution. To exactly 10 ml of exactly $M/20$ hydrazinium chloride in a stoppered flask is added about 25 ml concentrated hydrochloric acid and about 5 ml carbon tetrachloride or chloroform. This is titrated with a standard solution of potassium iodate with vigorous shaking until the organic layer becomes colorless. This experiment demonstrates the reaction of iodate in strongly acid solution, i.e.,

$$IO_3^- + 6H^+ + 4e^- \rightarrow 3H_2O + I^+$$

The ratio of reactants is found to be 1 mole hydrazine to 1 mole iodate and the product of the reaction must evidently have been nitrogen. The reaction can therefore be represented by

$$N_2H_4 + IO_3^- + 2H^+ \rightarrow N_2 + I^+ + 3H_2O$$

Oxidation States of Vanadium.[2] A solution of vanadium(V) is prepared by dissolving either about 1.5 g of vanadium pentoxide or about 2 g of ammonium vanadate in about 20 ml 3 M sodium hydroxide solution. The solution is then strongly acidified with dilute sulfuric acid (about 50 ml 2.5 M H_2SO_4) and diluted with distilled water to give a total volume of about 250 ml.

A 25 ml aliquot of this solution is reduced by bubbling sulfur dioxide gas through the hot liquid until it has become clear blue. Excess sulfur dioxide is then expelled by boiling vigorously for a few minutes, and the hot solution is titrated with an approximately 0.02 M solution of potassium permanganate. This is repeated until 2 or 3 concordant results are obtained.

A 25 ml aliquot of the same vanadium(V) solution is reduced by shaking with zinc amalgam (or by passage through a Jones reductor) until the color has become violet. The color changes which can usually be observed are:

	yellow →	green →	blue →	green →	violet
corresponding to	V^V	V^V and V^{IV}	V^{IV}	V^{III}	V^{II}

The violet solution containing V^{2+} cannot easily be titrated directly because it is so unstable that it readily undergoes aerial oxidation. It is better to pour it into an excess of an iron(III) solution which will produce an equivalent amount of iron(II), or into an excess of the original vanadium(V) solution.

In either case, the hot solution is titrated with the same permanganate solution used before. If the reduction of vanadium has gone to completion and if aerial oxidation has been successfully avoided, the two titration results are found to be in the ratio of 1/3. This shows that if in the first experiment, vanadium(V) had been reduced to vanadium(IV), i.e., by one step, then in the second, the vanadium(V) must have been reduced to vanadium(II), i.e., by three steps.

The appropriate equations for the reductions can be written in a number of different ways because vanadium(V) exists in the form of different ions in aqueous solution depending on the pH, the concentration and the temperature. To avoid undue complications it is convenient to assume that the ion is either VO_2^+ (known to exist in strongly acidic solutions) or VO_3^- (possibly $[V_3O_9]^{3-}$ as in ammonium vanadate, NH_4VO_3).

We have then in the first case,

$$2VO_2^+ + SO_2 \rightarrow 2VO^{2+} + SO_4^{2-}$$

or

$$2VO_3^- + SO_2 + 4H^+ \rightarrow 2VO^{2+} + SO_4^{2-} + 2H_2O$$

and in the second case,

$$2VO_2^+ + 3Zn + 8H^+ \rightarrow 2V^{2+} + 3Zn^{2+} + 4H_2O$$

or

$$2VO_3^- + 3Zn + 12H^+ \rightarrow 2V^{2+} + 3Zn^{2+} + 6H_2O$$

In the reaction of vanadium(II) with excess of iron(III) or with excess of vanadium(V), vanadium(IV) is produced.

$$V^{2+} + 2Fe^{3+} + H_2O \rightarrow VO^{2+} + 2Fe^{2+} + 2H^+$$

or

$$V^{2+} + 2VO_2^+ + 2H^+ \rightarrow 3VO^{2+} + H_2O$$

or

$$V^{2+} + 2VO_3^- + 6H^+ \rightarrow 3VO^{2+} + 3H_2O$$

In the titrations with permanganate, vanadium(IV) is oxidized to vanadium(V).

$$5VO^{2+} + MnO_4^- + H_2O \rightarrow 5VO_2^+ + 2H^+ + Mn^{2+}$$

or

$$5VO^{2+} + MnO_4^- + 6H_2O \rightarrow 5VO_3^- + 12H^+ + Mn^{2+}$$

and iron(II) is oxidized to iron(III)

$$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + 4H_2O + Mn^{2+}$$

[2] This is a variation of an experiment given by PALMER, W. G., "Experimental Inorganic Chemistry," Cambridge University Press, 1954, p. 318.

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Preparation of Diphenylmethane

Simplified procedure: purer product

The preparation of diphenylmethane as an example of the Friedel-Crafts synthesis is included in several manuals of organic laboratory practice.[1–3] Directions call for the slow addition of anhydrous aluminum chloride to a mixture of dry benzene and benzyl chloride in an ice bath, followed by refluxing for 30 min. The work-up is standard: hydrolysis of the reaction mixture followed by washing, drying, and a final atmospheric distillation.

The experience in our elementary organic chemistry laboratory was that the diphenylmethane was frequently contaminated with a yellow fluorescent impurity. We assumed that this impurity was anthracene.[1] A single simple atmospheric distillation usually failed to separate the diphenylmethane from all of the impurity. Fractionation under reduced pressure was successful in producing a water-white product, but this method is impractical for some classes with limited laboratory experience or those with limited apparatus.

In an effort to eliminate the formation of the impurity, two approaches were tried, both involving a decrease in the amount of aluminum chloride used. Only simple atmospheric distillation was employed in all experiments. One set of experiments followed the standard procedure,[2] varying the amount of aluminum chloride. The second set, again varying the amount of aluminum chloride, was run with a modified procedure involving the elimination of the refluxing period; the entire reaction was completed in the cold in less than 20 min. Summaries of the results of these trials are found in Table 1 and Table 2.

Table 1. Standard Procedure

Moles $AlCl_3$/mole $C_6H_5CH_2Cl$	0.280	0.140	0.050	0.025	0.015
Per cent yield	31	48	55	54	26

As the amount of catalyst was decreased from the standard amount[2] of 0.280 moles of aluminum chloride per mole of benzyl chloride, it was found that there is a direct qualitative relation between the amount of catalyst used and the amount of yellow to orange impurity in the diphenylmethane product; the less aluminum chloride used, the less colored the product.

Table 2. Modified Procedure

Moles $AlCl_3$/mole $C_6H_5CH_2Cl$	0.280	0.140	0.050	0.025	0.015
Per cent yield	47	44	51	48	22

By eliminating the reflux period a product was obtained which was free of all colored impurity. This modified procedure gives yields which are only slightly lower than those obtained by the standard procedure. As Table 2 shows, the yield is not greatly affected by the level of catalyst above 0.025 moles of aluminum chloride per mole of benzyl chloride, while lesser amounts of catalyst result in decreased yield. One laboratory manual[1] eliminates refluxing, but suggests letting the reaction mixture stand at room temperature for 30 min. As shown by the above results, this is not necessary. A good yield of clear product is obtained with no delay, the reaction time being only the time (15–20 min) for the slow addition of the aluminum chloride in the cold bath.

As a result of this investigation, the elimination of the reflux period as a laboratory technique was tried by two laboratory sections this year and proved successful. The students used only 0.025 moles of aluminum chloride per mole of benzyl chloride, no refluxing or period of standing and distilled the product at atmospheric pressure from a simple distilling flask. None of the 45 products was the slightest bit colored.

It can be concluded, then, that by elimination of the time-consuming reflux period a purer diphenylmethane product can be obtained. Moreover, the amount of aluminum chloride used can be reduced to about one-tenth the amounts suggested in the standard procedure.[1–3]

A simplified apparatus was used with the modified procedure as the initial reaction need not take place in a reflux apparatus. Instead, the initial reaction was done in an Erlenmeyer flask which was connected to a trap to eliminate hydrogen chloride vapors.

The author would like to thank Dr. Frank L. Lambert for his encouragement during this investigation.

[1] Fieser, L. F., "Experiments in Organic Chemistry," 3rd ed., D. C. Heath and Company, Boston, 1957, pp. 157–8.
[2] Robertson, G. R., and Jacobs, T. L., "Laboratory Practice of Organic Chemistry," 4th ed., Macmillan Company, New York, 1962, pp. 272–3.
[3] Vogel, A. I., "Practical Organic Chemistry," 3rd ed., Longmans, London, 1961, pp. 513–4.

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α-Pinene, a Starting Material for a Sequence of Organic Experiments

This paper presents a unified sequence of experiments which illustrates the unit operations and unit processes of organic chemistry and includes, unlike most laboratory texts, rearrangements and steroisomerism (*1*) exemplified by the chemistry of the terpenes. The chemistry of turpentine is among the most thoroughly developed fields of organic chemistry. α-Pinene, a principal constituent of turpentine, can serve as a starting material for a broad scale series of experiments 2–7, furthermore, the student will become familiar with a sizable segment of agricultural chemistry.

In this particular series of steps, a student may learn the operations of crystallization; fractional, steam, ordinary, and vacuum distillation; optical rotation; and determination of melting points. Unit processes illustrated are addition of hydrogen chloride to double bonds, rearrangements, hydrolysis of oximes, saponification, ozonolysis, permanganate oxidation, nitration, and chromic acid oxidation, Béchamp reduction, and nitric acid oxidation of side chains. Primarily, alicyclic and aromatic reactions are covered. The accompanying flow sheet illustrates the experiments which are recommended.

Experiment 1. A reasonable amount of commercial turpentine oil is dried with sodium sulfate and fractionally distilled. The α-pinene (I *a*), distills at 154–155°C, and the β-pinene (I *b*) at 163–164°C. Their optical activity may be determined in a student polarimeter like the one described by Shaw (*8*).

Experiment 2. The α-pinene (I *a*) treated at low temperature (−10°C) with anhydrous hydrogen chloride rearranges to give bornyl chloride (II) in 50–60% crude yield. Two recrystallizations from ethanol raises the melting point to 127°C (*9*).

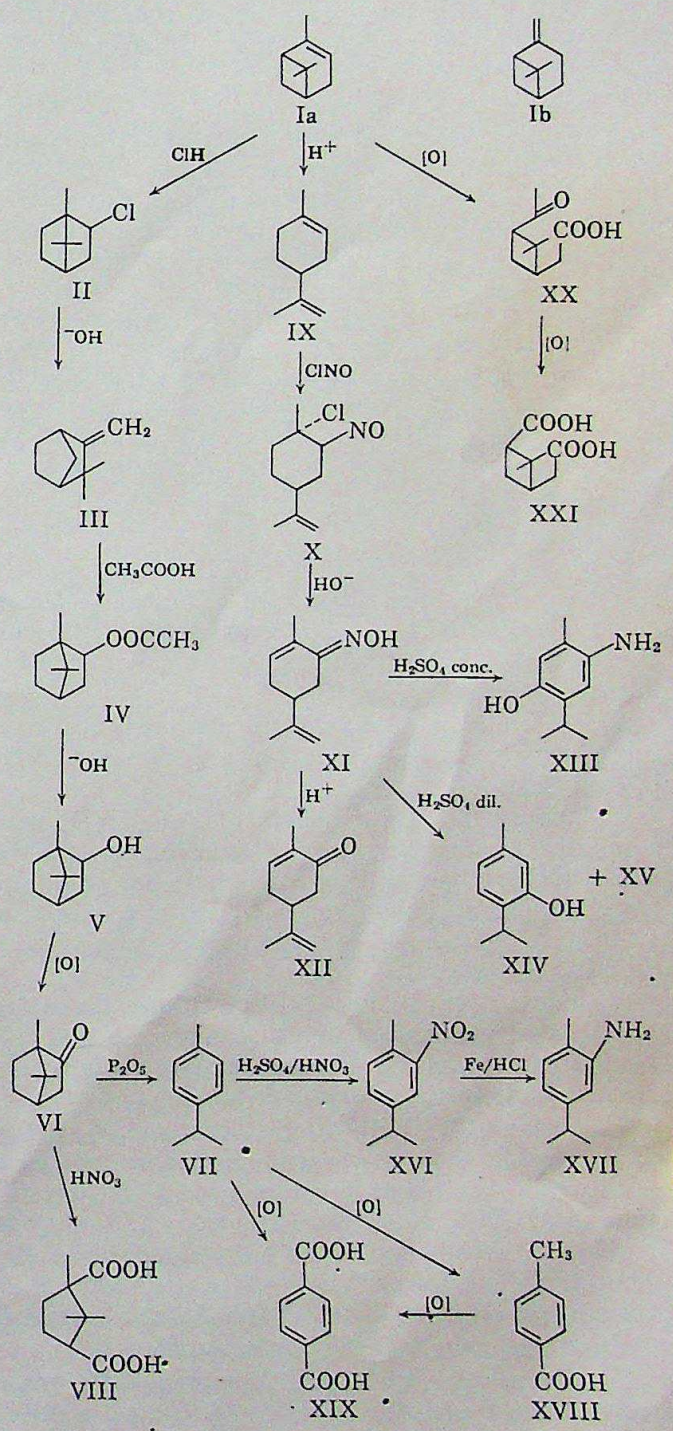
Experiment 3. When (II) is refluxed for two or three hours with a mixture of phenol (or cresol) and potassium hydroxide (*9*), hydrogen chloride is eliminated and, in a Wagner-Meerwein rearrangement, (II) is converted into camphene (III), bp 155–160°C. The distillate solidifies to crystals, mp 42–43°C. Camphene may be obtained directly from (I) by acid isomerization (*10, 11*). Chlorination of (III) gives the important insecticide toxaphene.

Experiment 4. Refluxing (III) for three hours with a mixture of acetic and sulfuric acids produces isobornyl acetate (IV) in 70% yield, bp 107°C (15 mm).

Experiment 5. The ester (IV) is saponified by refluxing it with sodium hydroxide in ethanol (*9, 12*). On dilution with water the isoborneol (V) is collected, dried, and recrystallized, mp 203–205°C, 80%.

Experiment 6. The isoborneol (V) is oxidized with chromic acid in acetic. The camphor (VI) formed melts at 170–174°C, 60%. It may be purified by sublimation.

Experiment 7. By mixing camphor (VI) with phosphoric anhydride (P_2O_5) and distilling slowly, the *p*-cymene (VII) is obtained by dehydration of (VI) (*13*). The yield is 60–80%. By an unusual Étard's reaction, Strubell (*14*) has prepared the α-tolyl propionaldehyde from (VII).



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Experiment 8. When a suspension of camphor (VI) in diluted nitric acid is heated for several hours, camphoric acid (VIII) is produced in 70–80% yield, mp 184–185°C.

Experiment 9. (This experiment may be started at the beginning of the series and in the meantime experiments 2 to 8 may be worked out.) Refluxing α-pinene for 30–40 hours with trichloroacetic acid in the presence of formamide or acetamide (*15*), and then by fractional distillation, gives limonene (IX), bp 176–178°C, in 40–60% yields. A faster preparation of (IX) is accomplished by thermal isomerization of α-pinene (*16–19*).

Experiment 10. At low temperature (−10°C) limonene (IX) reacts with the nitrosyl chloride (from a mixture of isopropyl alcohol, sodium nitrite, and hydrochloric acid, as described by Reitsema (*20*), or from *n*-butyl nitrite, acetic acid, and hydrochloric acid, sp gr 1.155 (*21, 22*). The limonene nitrosochloride (X) is collected and immediately crystallized from a mixture of chloroform and methanol (1:3). Compound (X) melts at 104–105°C.

Experiment 11. The isomerization of (X) is accomplished by heating it with a mixture of urea and isopropyl alcohol (*23*) or pyridine and acetone (*23, 24*). The latter method gives carvone oxime (XI), in 90–95% yield. Our students have been unable to obtain (XI) by refluxing (X) with dimethylformamide and isopropyl alcohol as described in (*20*).

Experiment 12. Carvoxime (XI) is hydrolyzed with dilute oxalic acid (*13, 23, 24*) to carvone (XII). This ketone is the principal component of spearmint oil. The rearrangement of (XI) to 6-aminothymol (XII) using concentrated sulfuric acid (*25*) has been described as well as its conversion to a mixture of 2-amino-*p*-cymene (XI) and carvacrol (XIV) when dilute sulfuric acid is used (*26*).

Experiment 13. The limonene (IX) (which also may be obtained by steam distillation of orange or lemon peels) is converted to a mixture of cymene (VII) and *p*-menthane (XVI) by refluxing it with a copper nickel formate catalyst (*13, 15, 27*).

Experiment 14. With a sulfuric and nitric acid mixture, the *p*-cymene (VII) gives 2-nitro-*p*-cymene (XVII) in good yields (*28, 29*).

Experiment 15. By reduction (*30*) of (XVII) with a mixture of iron powder and hydrochloric acid the amine (XV) is produced. This amine has been also obtained (*29*) in high yields by hydrogenation of (XVII) at high temperature and pressure using Raney nickel as the catalyst.

Experiment 16. By the usual procedures the amine (XV) may be converted to a diazonium salt and this coupled to phenols or aromatic amines to form azo dyes, or hydrolyzed to carvacrol (XIV).

Experiment 17. With dilute nitric acid, *p*-cymene (VII) is oxidized to *p*-toluic-acid (XVIII) in good yield (*31*). By a more drastic oxidation of (VII), terephthalic acid (XIX) is formed. The acid (XIX) may be purified by sublimation under reduced pressure. Refluxing (XIX) with methanol and a little amount of sulfuric acid produces dimethyl terephthalate, which is used for the production of Dacron-like fibers.

Experiment 18. By potassium permanganate oxidation of dextro α-pinene (*6*) at −50°C in a solution buffered with ammonium sulfate, then filtration of the manganese dioxide formed, concentration of the solution, and another filtration followed by acidification to *p*H 1–2 with sulfuric acid, a mixture of solid and liquid pinonic acid (XX) is obtained. These are separated by filtration. Better yields and a cleaner product are obtained by ozonolysis of the α-pinene (*32–34*) in acetic acid or oxidation with peroxides (*35*). Many reactions of pinonic acid (XX) have been mentioned (*6*).

Experiment 19. Calcium hypochlorite in aqueous solution degrades pinonic acid to pinic acid (XXI). Its esters have been proposed as plasticizers.

Literature Cited

(1) Fieser, L. F., J. Chem. Educ., **31**, 291 (1954).
(2) Suga, K., and Watambe, S., *Chiba Daigaku Kogabubu Kenkyu Hokoku*, **8**, 37 (1957); cited in *C.A.*, **54**, 5021h (1960).
(3) Newhall, W. F., *J. Org. Chem.*, **23**, 1274 (1958).
(4) Patrick, R., and Newhall, F., *J. Agric. Food Chem.*, **8**, 397 (1960).
(5) Strubell, W., *Acta Chim. Scient. Hung.*, **24**, 475 (1960) for leading references.
(6) Stinson, J. S., and Lawrence, R. V., *J. Org. Chem.* **19**, 1047 (1954).
(7) Hedrick, G. W., and Lawrence, R. V., *Ind. Eng. Chem.* **52**, 853 (1960).
(8) Shaw, W. H. R., J. Chem. Educ. **32**, 10 (1955).
(9) Fisher, H. L., "Laboratory manual of Organic Chemistry," 4th Ed., John Wiley, New York, pp. 255–265 (1938).
(10) Meerwein, H., *Ann.* **405**, 129 (1914).
(11) Wagner, G., and Brykner, W., *Ber*, **33**, 2121 (1900).
(12) Richter, G. H., "Laboratory manual of elementary Organic Chemistry," 2nd ed., John Wiley, New York, p. 49 (1951).
(13) Hayes, F. N., Hansbury, E., and Kerr, V. N., *Anal. Chem.* **32**, 617 (1960).
(14) Strubell, W., *J. Prakt. Chem.*, (4) **10**, 349 (1960).
(15) Kharasch, M. S., and Reynolds, W. B., *J. Org. Chem.*, **9**, 148 (1944).
(16) Conant, J. B., and Carlson, *J. Am. Chem. Soc.*, **51**, 3464 (1929).
(17) Smith, D. F., *J. Am. Chem. Soc.*, **49**, 43 (1927).
(18) Thurber, F. H., and Johnson, C. H., *J. Am. Chem. Soc.*, **52**, 786 (1930).
(19) Verghese, J., and Kuriacose, J. C., *J. Scient. Ind. Research* (India), **18B**, 364 (1954).
(20) Reitsema, R. H., *J. Org. Chem.*, **23**, 2038 (1958).
(21) Commanday, S., and Cheronis, N. D., *Microchem. J.*, **4**, 201 (1960).
(22) Rupe, H., *Helv. Chim. Acta* **4**, 148 (1921).
(23) Royals, E. E., and Horne, S. E., *J. Am. Chem. Soc.*, **73**, 5856 (1951).
(24) Bordenca, C., and Allison, R. K., *Ind. Eng. Chem.*, **43**, 1196 (1951).
(25) Wallach, O., and Schrader, H., *Ann.*, **279**, 366 (1894).
(26) Wallach, O., Kruse, H., and Kerhkoff, F., *Ann.*, **275**, 103 (1893).
(27) Palmer, R. C., and Bibb, C. H., U.S. patent 2211-432.
(28) Kobe, K. A., and Doumoni, T. F., in "Organic Synthesis," Coll. Vol. 3, Horning, E. C., ed., John Wiley & Sons, New York, **1955**, p. 653.
(29) Doumani, T. F., and Kobe, K. A., *Ind. Eng. Chem.*, **31**, *264* (1939).
(30) Allen, C. F. H., and Van Allen, J., in "Organic Synthesis," Coll. Vol. 3, Horning, E. C., ed., John Wiley & Sons, New York, **1955**, p. 63.
(31) Tuley, W. F., and Marvel, C. S., in "Organic Synthesis," Coll. Vol. 3, Horning, E. C., ed., John Wiley & Sons, New York, **1955**, p. 822.
(32) Fisher, G. S., and Stinson, J. S., *Ind. Eng. Chem.*, **47**, 1569 (1955).
(33) Holloway F., Anderson, H. J., and Rodin, W., *Ind. Eng. Chem.*, **47**, 2111 (1955).
(34) Loeblich, V. M., Magne, F. C., and Mod, R. R., *Ind. Eng. Chem.*, **47**, 855 (1955).
(35) Sugarman, N., and Daugherty, P. M., *Ind. Eng. Chem.*, **48**, 1831 (1956).

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Esterification for the Introductory Organic Laboratory Course

A modified Dean-Stark trap

The process of esterification, or its reversal, is often used in the physical chemistry course as a laboratory experiment to demonstrate attainment of equilibrium from various directions, or as an easily followed kinetic study. A survey of esterification experiments in some of the widely used organic laboratory manuals shows that while the equilibrium nature of the reaction is usually discussed, the actual experiments chosen for laboratory practice do not seem to give the student the fullest possible appreciation of the phenomena in physical terms. Most of the manuals call for the use of a large excess of alcohol. Another technique which can be used to advantage in systems where water is one of the products of the reaction is that of removing the water as it is formed by azeotropic distillation. Brewster, VenderWerf, and McEwen,[1] and Robertson and Jacobs,[2] provide alternate esterification experiments in which this principle is used, but the procedures seem more time-consuming and less convenient than that described here.

A simple technique which makes possible continuous azeotropic removal of water along with solvent recycling employs a trap of the type described by Dean and Stark,[3] and is widely used in industrial practice in the preparation of polyesters. A variety of inert solvents will form an azeotropic system. The solvent chosen should form an azeotrope with water which is the lowest boiling of all the possible components in the mixture. Also the boiling point of the solvent must permit easy separation from the desired product. Benzene which forms an azeotrope of 8.8% water boiling at 69.3° is particularly convenient. The preparation of γ-chloropropyl acetate in 93–95% yield by this method has been described in detail.[4]

Such an experiment has not been suggested for the beginning organic course probably because of the relatively high cost of purchasing such traps. At a negligible cost of materials, however, traps can be made from a standard 20 × 150 mm Pyrex test tube and 12 mm od Pyrex tubing. A side arm is sealed onto the test tube approximately 50 mm from the top. A right angle bend is made in the side arm about 100 mm from its joint with the test tube, and the side arm is then cut and polished about 50 mm below the bend. The experiment is set up by attaching a round bottom flask to the side arm, and an upright condenser to the test tube. The flask is charged with the reactants and solvent, and the trap is filled to the side arm return with solvent. The mixture is heated to reflux; and as the reaction occurs, the condensate from the refluxing mixture separates, and the heavier water layer is retained in the bottom of the trap, while the solvent is returned by overflow to the reaction flask.

As a senior project, a student determined optimum conditions for the preparation of *n*-amyl acetate by this method in terms of mole ratios of reactants, amount of catalyst, and reaction time. The study indicated that best results are obtained on a convenient scale by refluxing a mixture of 0.25 mole of acetic acid, 0.20 mole of *n*-amyl alcohol, 30 ml of benzene, and 0.15 g of *p*-toluenesulfonic acid (catalyst) for one hour. At the conclusion of this time, water evolution is essentially complete. Usually, about 10–15% more than the theoretical amount of water is given off, due to a combination of water present in the commercial reagents and to some entrainment in the vapor of the alcohol or acid. The reaction mixture is worked up by extracting with sodium bicarbonate solution to remove excess acid, washing with water, and then with saturated sodium chloride solution. The organic layer is distilled through a fractionating column to remove the bulk of the benzene (and any residual water as an azeotrope), and when most of this has distilled, the residue is transferred to a small distillation flask containing a small plug of steel wool in the neck and the product is isolated by simple distillation.

For 100 student preparations, the average yield of *n*-amyl acetate, bp 141–146°, was 71%. The quality of the preparations may be easily checked by taking an infrared spectrum. The most likely contaminants are *n*-amyl alcohol (which boils within 10° of the ester) and benzene. These may be readily detected in the presence of *n*-amyl acetate, since the alcohol shows the typical OH band near 3500 cm^{-1}, and benzene has absorptions close to 1970 cm^{-1} and 1820 cm^{-1}, regions where the pure ester does not absorb.

A study also was made of the yields of esters which could be obtained under similar reaction conditions from a variety of common alcohols and acids. The results are given in the table.

Longer reaction time was needed with a secondary alcohol. The yield of *sec*-butyl acetate after one hour was 26%; after 2 hours, 40%. No water evolution or ester product was obtained with *tert*-butyl alcohol even after 4 hours reaction time. While *n*-butyl, *iso*-butyl,

[1] Brewster, R. Q., VanderWerf, C. A., and McEwen, W. E., "Unitized Experiments in Organic Chemistry," D. Van Nostrand Company, Princeton, N. J., 1960, p. 108.

[2] Robertson, G. R., and Jacobs, T. L., "Laboratory Practice in Organic Chemistry," 4th ed., The Macmillan Company, New York, 1962, p. 228.

[3] Dean, E. W., and Stark, D. D., *Ind. and Eng. Chem.*, 12, 486 (1920).

[4] Horning, E. C., ed., "Organic Synthesis," Coll. Vol. 3, John Wiley and Sons, New York, 1955, p. 203.

Presented at the April, 1960 Meeting of the Pennsylvania Association of College Chemistry Teachers, Gettysburg, Pa.

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n-propyl, and *iso*-propyl acetates can be prepared in good yields by this procedure, difficulty was encountered in getting clean separation of these lower boiling esters from the starting alcohol and the benzene by simple distillation. This was indicated by the wider boiling ranges and by infrared examination of the products.

Yields of Esters from Alcohols and Acids Using Azeotropic Esterification Method

Alcohol	Acid	Reaction time hours	Ester yield %
n-Amyl	Acetic	1	75
iso-Amyl	Acetic	1	65
n-Butyl	Butyric	2	66
n-Butyl	Propionic	2	58
n-Butyl	Acetic	1	65
iso-Butyl	Acetic	1	60
sec-Butyl	Acetic	4	71
tert-Butyl	Acetic	4	0
n-Propyl	Acetic	1	67
iso-Propyl	Acetic	1	63

Student response to the experiment has been good, and a number always comment that this was one reaction they could actually "see" going. There are several variations which can be used, if desired, to illustrate further principles. The reaction may be followed kinetically by having the students calibrate the trap and measure water evolved versus time. The effect of catalyst can be demonstrated by having the students reflux the charge without catalyst for some time, then add catalyst and observe the rapid increase in water evolution. The effect of structure on the reactivity of alcohols toward esterification may be shown by giving different sections of the class a primary, secondary, or tertiary alcohol as starting material and have them observe and report relative reaction rate and yield after a specified period of heating.

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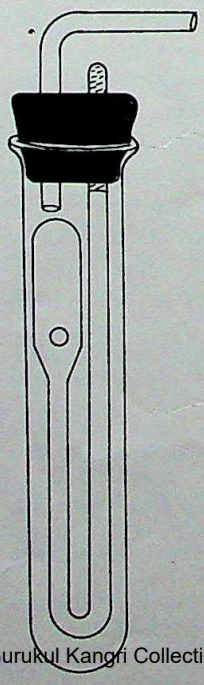
A Simple Closed End Manometer

There are frequent uses in the laboratory for simple manometers to measure pressures in the range of 1–100 mm of mercury. The instrument described here has been used by our students in introductory organic chemistry and has demonstrated certain advantages over previous designs. Probably the most significant is the fact that the glass tubing by which the manometer is attached to the evacuated system is not rigidly connected to the manometer tube proper and breakage in assembling and taking down the systems is greatly reduced. In use the instrument can be held in standard clamps and a number of manometers can be stored in a small space in a box with suitable compartments to hold the tubes in a vertical position. The design minimizes spillage of mercury.

In so far as possible the manometer is constructed from standard glassware. The outer tube is a 38 × 200 mm test tube fitted with a no. 8 two-holed stopper. To connect the manometer to the evacuated system a length of 8 mm tubing or a T-tube may be used, although for permanent installations there are advantages to the use of a stopcock.

The manometer tube proper is constructed from a 12in. length of 7 mm tubing, a short piece of rod of the same diameter, and a test tube 16–18 mm in diameter. The bend at the bottom of the tube can be made smoothly in the flame of a Meeker burner when 7 mm borosilicate glass is used. The only point to note is the location of the hole in the side of the large tubing. This should be placed so that all the mercury needed for the column can be contained in the reservoir when the manometer is inverted and can be run in and out of the tube without loss. A strip of graph paper graduated in millimeters attached to the tube provides an inexpensive scale.

To fill the manometer, a suitable amount of mercury is placed in the reservoir. About 1 ml is needed for every 2 in. of column if 7 mm tubing is used. The mercury is conveniently measured and inserted using a 5 ml hypodermic syringe. The outer tube is put in place and the whole system evacuated with a mechanical pump and heated with an infrared lamp if desired. While evacuated, the manometer is righted, taking care that mercury is not lost through the hole above the reservoir. Air is now admitted to the system and the manometer is ready for use. When several manometers are to be filled, it is convenient to have a three-way stopcock between the pump and the manometer so that one can be released and another put on the line without disturbing the pump.



If the manometer becomes contaminated with volatile materials in use, the mercury can be drawn back into the reservoir and heated in vacuo until the contaminants are removed.

This design is an amalgamation of types observed by the author in the laboratories of Brown University and at the National Research Council of Canada.

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Low Temperature Zone Refining Apparatus

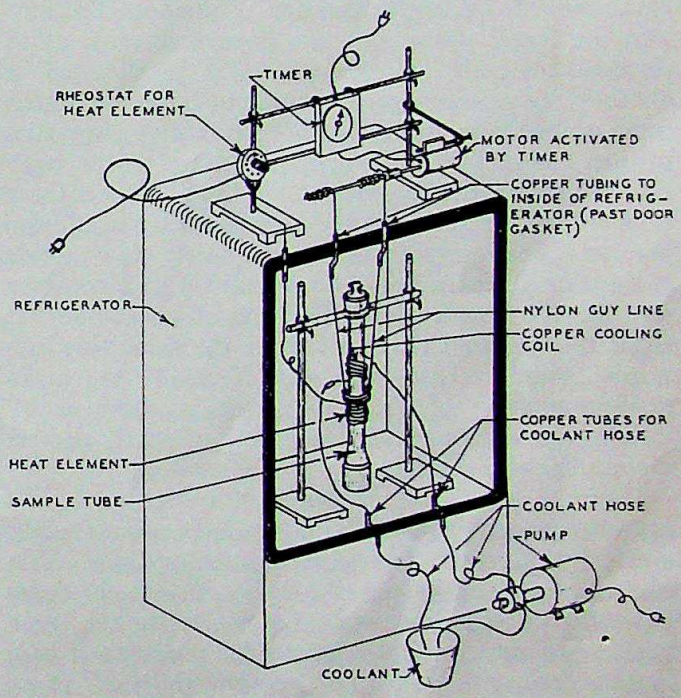
Zone refining, originally introduced in the purification of metals, is receiving increasing attention as a valuable tool for the laboratory purification of both inorganic and organic chemicals.[1] Commercial zone refining units, employing a moving hot zone, are now available for use with substances melting from 50 to 300°C. The zone refining of lower melting materials has received less attention. Herington and coworkers[2] suggested the use of a refrigerator in connection with zone refining of such materials but provided no details. Rock[3] described a novel variation consisting of a moving hot zone in a tube surrounded by a low-melting solid in an outer tube.

In the preparation of high-purity monomers which are liquid at room temperature, zone melting has now been found in this laboratory to be of great assistance, either alone or coupled with preliminary fractional distillation. A suitable assembly for zone melting at low temperatures was improvised from a column mounted in a household refrigerator and fitted with a sleeve carrying an electrically heated coil and a cooling spiral. The sleeve is driven by a low-speed motor coupled with a pulse timer. The assembly is shown schematically in the illustration.

Assembly Design

Remove the shelves from a household refrigerator and support a 30-in. length of Vycor tubing (1-in. outside diameter) vertically within the cabinet (34-in. height). Seal a 24/40 outer standard-taper joint to each end of the Vycor tube and close with a standard-taper glass stopper. Wind a $^7/_8$-in. sleeve with 10 feet of asbestos-wrapped #28 heating wire (3.8 ohms/ft. resistance). The sleeve, machined from a solid brass rod, has an inner opening $1^1/_{16}$-in. in diam and a top lip $^1/_{16}$-in. wide, $2^1/_2$-in. in diameter. The sleeve, when fitted over the Vycor tube, should provide $^1/_{32}$-in. clearance. Cover the top lip with sheet asbestos; support on the lip a closely wound copper coil $2^1/_2$-in. long, of $^1/_4$-in. diam copper tubing. When slipped over the Vycor tubing, this coil should provide $^3/_{32}$-in. clearance.

In use, fill the Vycor tube to a height of 15-inches with the compound in a liquid state. Close the tube with a glass stopper and then mount it vertically on a ring stand within the cabinet of household refrigerator. Slip the sleeve over the tube and top by the copper coil. Connect the heating wire of the sleeve to a variable transformer and this to a 110-volt source. Connect the copper spiral cooling coil to a reservoir of solid carbon dioxide and 1-methyl-2-propanol (Dowanol PM) placed outside of the refrigerator by plastic tubing and an electrically-driven rotary pump. Support the sleeve and cooling spiral by two lengths of nylon fishing line carried by $^1/_8$-in. copper tubing guides through the plastic gasket of the refrigerator door and fastened to the extended thin shaft of a one rpm motor (Bodine Electric Co., Chicago, Illinois; Type KYC-22RC) connected to a pulse timer (Flexopulse Timer, Eagle Signal Corp., Moline, Illinois), both of which are mounted on the top of the refrigerator.



In the purifications of interest the refrigerator was maintained at 5–6°C. and the heating zone and cooling coil descended the column at the rate of 1-inch per hour with the zone being heated just sufficiently to maintain a liquid zone. The coolant was maintained at −20 to −40°C.

In the initial study an ascending zone was used with a Pyrex tube. However, breakage was encountered caused by the expansion of the tube contents on melting. By adoption of a descending zone and the use of a Vycor tube this hazard was eliminated.

The assembly described has been used for the preparation of purified vinylene carbonate.[4] This monomer as prepared by the dehydrohalogenation of monochloroethylene carbonate melts at about 22°C

[1] Pfann, W. G., "Zone Melting," John Wiley & Sons, New York, 1958.
[2] Herington, E. F. G., Handley, R., and Cook, A. J., *Chem. & Ind.*, 1956, 292.
[3] Rock, H., *Fortsch. Physik. Chem.*, 2, 48 (1957).
[4] Newman, M. S., and Addor, R. S., *J. Am. Chem. Soc.*, 75, 1263 (1953).

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and contains 1.0–1.8% chlorine. Fractionation on a 4-ft., 1-in. column packed with stainless steel protruded packing (Scientific Development Co., State College, Pa.) affords a purified monomer containing 0.05% chlorine. This material on three consecutive passes through the low temperature zone assembly described yielded a product containing 0.005% chlorine (upper 30% of column). The crude monomer required a greater number of passes for similar purification; hence, a preliminary distillation seemed preferable.

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Automatic Apparatus for Zone Refining of Organic Substances

Zone refining[1] is one of the numerous zone melting[2,3] techniques which was described by W. G. Pfann as a "powerful tool for manipulating impurities in crystals." The essence of zone melting is taking advantage of the different solubilities of an impurity in the solid and liquid phases of the material being refined, i.e., crystallization of a pure substance from its liquid phase and not from a solvent, as in classical methods of refining. This purification is obtained by passing over the ingot of impure material some melted zones which "gather" and carry impurities toward one end of the ingot, according to the equilibrium segregation coefficient. This is frequently a slow process, for the impurity must move by a diffusion process. For zone refining an adequately slow motion of the zone (usually from 1 to 20 cm/hr) at a constant rate for the length of the ingot must be assured; a rapid return and the repetition of the same slow upwards motion is also required. Normally the automatic operation of such apparatus is obtained by rather expensive means: using sets of small electric motors, suitable gears, etc.

Figure 1 shows the principle of construction and operation of a refiner which may be built of simple laboratory equipment and give satisfactory use. The essential element is the floating disc, which floats upward with precision while water rises in the main vessel. In our experiments a wooden pipet stand base impregnated with paraffin to prevent the soaking up of water is used. When the water level reaches the highest bend of the siphon tube, the water will pour off to the initial level, as it would in a Soxhlet extractor. The zones then begin repeated migration.

The heaters are made from resistance wire ("canthal") wound 50 times around a 3-mm thick glass ring, and they are supplied with 220 v ac through a transformer. A temperature of 350°C is easily obtained in the center. The heaters are shielded with asbestos rings to focus the radiation. The asbestos ring laid on the stopper of the floating disc protects the water vapor equilibrium from disturbance when the disc approaches the lowest heater. Heavy copper wire heated at one end by a Bunsen burner may also be used as a heater.[4] A millimeter scale may be glued to the wall to measure the rise of the water level and thus measure the rate at which the melted zone moves.

A special application of this zone refiner would be a micro- or multi-refiner. A multi-refiner can be built in such a way that more tubes with purified substances are fitted on the floating disc; thus refining of mixtures of different concentrations may be observed and phase changes may be investigated.

To demonstrate this apparatus, naphthalene with an added dye such as methyl red or methyl violet has been found to be best. We have used bromocresol purple (about 0.1%). The result of the refining was very striking. There was no visual trace of the dye after two passages of the melted zone (1 cm width) at a velocity of 2.3 cm/hr on the 8 cm length from the initial position of the heaters. Only transparent, crystallized, ultra pure naphthalene was left.

[1] Paar, N. L., "Zone Refining and Allied Techniques," G. Newness, Ltd., London, 1960.
[2] Pfann, W. G., "Zone Melting," John Wiley and Sons, New York, 1958.
[3] Pfann, W. G., *Science*, 135, 1101 (1962).
[4] Herington, E. F. G., *School Sci. Rev.*, 149, 35 (1961).

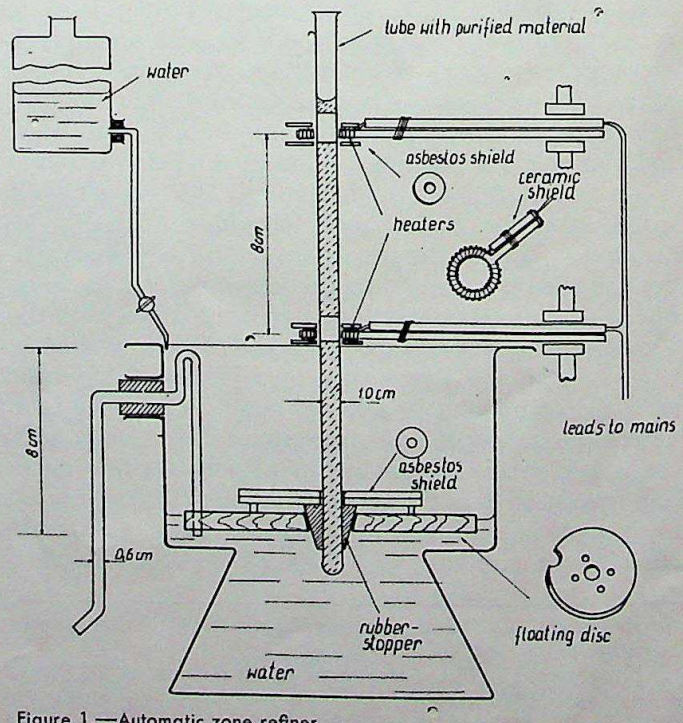

Figure 1.—Automatic zone refiner.

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A Simple Approach to the Second Law

What follows presupposes that the first law of thermodynamics has been discussed with students and that ideas of reversible processes, heat, and work have been introduced. It is assumed that entropy has not been introduced by definition, although even then the exercise is of value.

It is common practice to carry out a reversible Carnot cycle for one mole of ideal gas (whose mode of working is well understood) with the processes presented on a PV graph or "work diagram." It is found that the efficiency $\Sigma w/q_h$, is given by,

$$\frac{\Sigma w}{q_h} = \frac{T_h - T_c}{T_h} \tag{1}$$

where T_h and T_c refer to the hot and cold temperatures on the ideal gas scale.

It is also instructive to consider a cycle for *any* system (whose mode of working is, in general, not understood) operating reversibly with the processes shown on a graph of T against q_{rev}/T or "heat diagram" as in the drawing:

AB isothermal (T_h)	$q_{rev} = q_h$
BC adiabatic ($T_h \rightarrow T_c$)	$q_{rev} = 0$
CD isothermal (T_c)	$q_{rev} = q_c$
DA adiabatic ($T_c \rightarrow T_h$)	$q_{rev} = 0$

Around the cycle the change in internal energy, ΔE, is

$$\Delta E = \Sigma q - \Sigma w = 0$$

so that

$$\Sigma q = \Sigma w = q_h + q_c \tag{2}$$

By definition the efficiency is given by,

$$\frac{\Sigma w}{q_h} = \frac{q_h + q_c}{q_h} \tag{3}$$

Now define a thermodynamic temperature, θ, proportional to the positive value of the heat flow to or from the system at that temperature. The positive value of the heat flow to the system at T_h is q_h, and the positive value of the heat flow from the system at T_c is $-q_c$ (q_c having a negative value). Hence,

$$\frac{q_h}{\theta_h}^{1} = \frac{-q_c}{\theta_c} \quad \text{or} \quad q_c = -q_h \cdot \frac{\theta_c}{\theta_h}$$

and

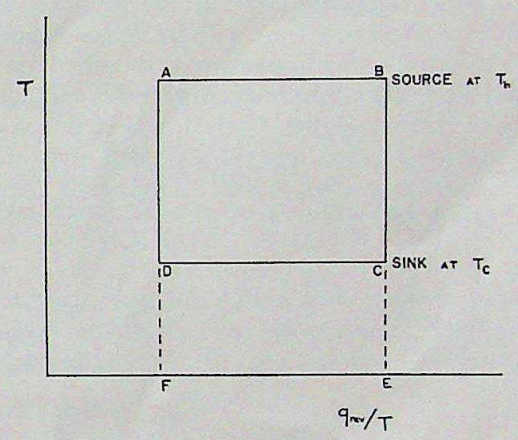
$$\frac{\Sigma w}{q_h} = \frac{q_h - \left(q_h \cdot \frac{\theta_c}{\theta_h}\right)}{q_h} = 1 - \frac{\theta_c}{\theta_h} = \frac{\theta_h - \theta_c}{\theta_h} \tag{4}$$

By comparing equations (1) and (4) these thermodynamic temperatures are seen to correspond to temperatures on the ideal gas scale.

[1] This relation provides justification for the diagram.

Most of the above is self-evident on the diagram where, for a beginner, the isothermal processes look isothermal and the adiabatic processes adiabatic. Referring again to the drawing, the over-all work done around the cycle is equal to the over-all heat transferred (since $\Delta E = 0$), which is the magnitude of the heat from the source on the outgoing isothermal process (area $ABEF$) minus the magnitude of the heat going to the sink on the returning isothermal process (area $DCEF$). Thus area $ABCD$ represents either the over-all heat transferred or the over-all work done around the cycle. The efficiency is:

$$\frac{\Sigma w}{q_h} = \frac{\text{area } ABCD}{\text{area } ABEF} = \frac{\text{length } AB(T_h - T_c)}{\text{length } AB(T_h)} = \frac{T_h - T_c}{T_h}$$



As the upper temperature is raised, the ratio of the above areas obviously increases; the efficiency is improved and will approach unity as T_h approaches infinity. As the lower temperature is decreased, improved efficiency is again achieved and there is also a limit. When T_c approaches zero, the efficiency again approaches unity; no heat is rejected at this temperature, and all the heat absorbed at the higher temperature is converted into work. To achieve any higher efficiency than this would violate the law of conservation of energy (first law). In this respect the second law is a particular case of the first. Or, considered in another way, any temperature lower than zero is unattainable.

To be more explicit, the efficiency expression is a form of the second law which, in the lower limit ($T = 0$) becomes,

$$w = q, \quad (\Delta E = 0)$$

and this is a particular statement of the first law. A similar argument could be applied in the case of the upper limit.

Statement of the Second Law. At a sink temperature of zero on the thermodynamic or ideal gas scales, it is

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just theoretically possible to convert heat completely into work by a cyclic, reversible process; whereas with the sink at any higher temperature this is impossible and for the conversion of some of the heat to work a price must be paid in the form of heat rejected into the sink, but it is a bargain price if the process is reversible. If the process is irreversible, the price is higher for less work. This complies with experience.

Instructors in thermodynamics will immediately identify the plot in the drawing as a TS graph. Examples are given in many textbooks and used extensively by engineers, so that nothing original is implied except that by its use in the above manner the following are achieved: concepts are presented clearly on a graph; the first and second laws are correlated; thermodynamic temperatures are introduced and related to the ideal gas scale; the application to a refrigeration cycle follows immediately. The student has herein used the concept of entropy and so it should cause him less alarm when it is now defined and given further meaning. The above diagram is most adaptable to the presentation of multiple and elemental Carnot cycles and the properties of q_{rev}/T as a state function are apparent on the diagram.

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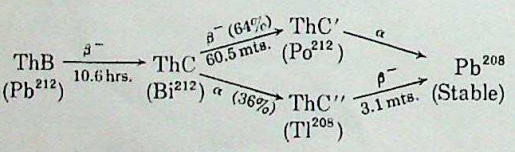
Genetically Related Radionuclides

Growth-decay studies of ThB-ThC

One of the elementary experiments in a first course in radiochemistry at the graduate level is the study of the growth of a short lived radionuclide from its relatively long lived parent, thereby illustrating their genetic relationship. Many pairs of radionuclides have been recommended (*1–5*) for this purpose. Of these, one which has convenient half-lives for the purpose in view is ThB (Pb^{212})-ThC (Bi^{212}) with the following decay scheme:



Dillard and Morton (*5*), who recommended this pair before, have suggested the isolation of carrier-free ^{212}Pb-^{212}Bi and following the decay of the same. From this data, the growth curve of the daughter from the parent and the independent decay of the pure daughter are computed. The more direct aspect of following the growth of a daughter from an initially pure parent is not included.

Our purpose in this paper is to describe an experimental demonstration of the different relationships that exist in the activities of a pair of genetically related radionuclides which will help the student to grasp the basic concepts.

The Experiment

ThB is isolated in a radiochemically pure form from thorium nitrate by solvent extraction (*6*). If the β^- activity of the isolated ThB is measured, it will be found to increase gradually with time because of the growth of ThC (and ThC″) from ThB. From this measurement the student determines:

(1) The growth of ^{212}Bi from its initially pure parent ^{212}Pb.

(2) The time of maximum activity of the mixture (T_{max}) and the daughter (T'_{max}) and compares them with the theoretical values (*1*).

(3) The half-life value with which the system (as well as the daughter) decays after reaching equilibrium.

(4) The half life of the pure daughter from its rate of decay.

Special reagents: thorium nitrate; lead carriers: 10 mg Pb/ml and 100 μg Pb/ml; bismuth carriers: 10 mg Bi/ml and 100 μg Bi/ml; 0.02% w/v dithizone in CCl_4.

Procedure

Dissolve 2 g thorium nitrate, 100 μg each of lead and bismuth, 5 g citric acid, and 2 g tartaric acid in 20 ml distilled water. Adjust the *p*H to 9.5 using phenolphthalein. Extract twice with 20 ml of 0.02% dithizone in CCl_4.

Organic layer:
Scrub with dilute ammonia (*p*H 9.5).

Aqueous layer:
Discard.

Organic layer:
Extract twice with 0.001*M* HCl (note time).

Aqueous layer:
Discard.

Organic layer (contains Bi):
Extract with 1*M* HCl, and discard the organic layer. The aqueous layer contains the Bi. Add 10 mg of Bi; ppt. with H_2S; filter; dry; mount and count for 2 hrs at 15 min intervals

Aqueous layer (contains Pb):
Add 10 mg of Pb; ppt. with H_2S; filter; dry; mount and count for 4 hrs at 15 min intervals; and then for 4 hrs[1] at 1 hr intervals.

[1] If there is insufficient time, count the following day. Measured activities were corrected for coincidence and background.

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Typical experimental growth-decay curves are shown in Figures 1 and 2. In Figure 1, curve *a* is the plot of the observed gross activity of the system as a function of time on a semilog paper. From this plot T_{max} is determined. The growth portion of curve *a* is extrapolated to zero time (as indicated by the dotted line). Through this activity at zero time curve *b* is drawn parallel to the decay portion of curve *a*. This represents the decay of the pure parent. Subtraction of curve *b* from curve *a* gives curve *d* which represents the activity of ^{212}Bi from an initially pure ^{212}Pb. From this plot T_{max}' is determined. Extrapolation of the

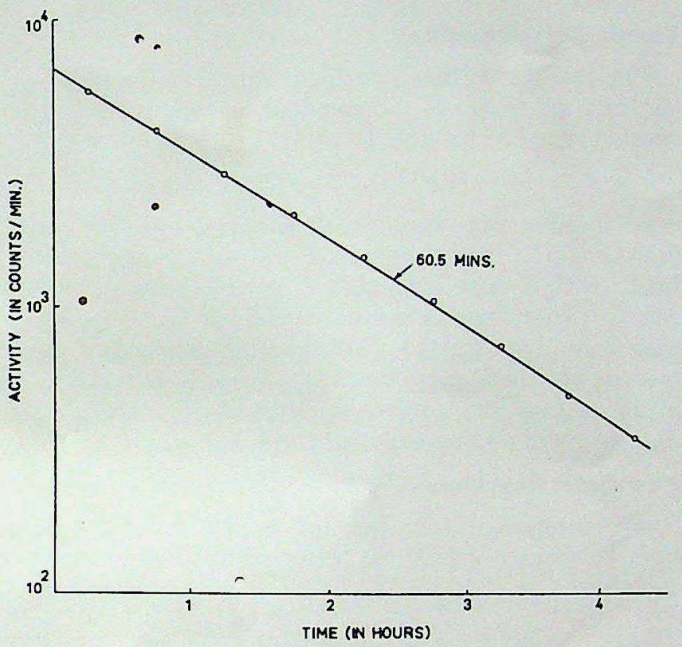

Figure 2. Decay of freshly isolated Bi-212

decay portion of curve *d* to zero time gives curve *e*. Subtraction of curve *d* from curve *e* gives curve *c*, which represents the decay curve of pure ^{212}Bi in absence of its growth from ^{212}Pb. From curve *c* the half life of ^{212}Bi is found and compared with an independent measurement on the pure ^{212}Bi fraction given in Figure 2.

In Table I a comparison is made between the genetically related pairs of radionuclides used for teaching and the recommended ThB-ThC system.

From the table, it is clear that for the pairs (1), (2), (3), and (4), T_{max}' is very long, ranging from a few days to a few months. The duration of the experiment is naturally long. On the other hand, for the pairs (5) and (6) T_{max}' is very short which calls for a very quick chemical separation so as to observe any noticeable growth.

Again pairs (2), (3), (4), (5), and (6) are the cases of secular equilibria so that it is not practically possible to demonstrate the rate of decay of the system after it attains equilibrium. With normal facilities students can gain maximum information from this single experiment performed in about 8 working hours.

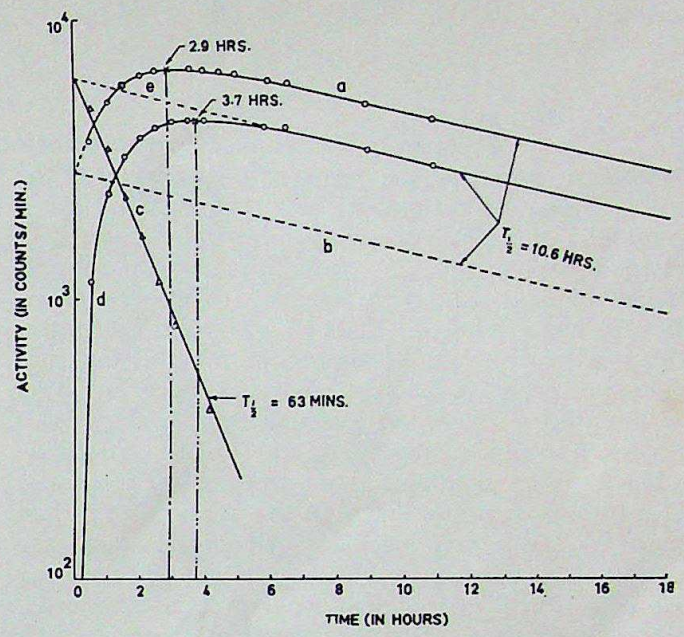

Figure 1. Letters on the graph represent: (*a*) total activity of an initially pure Pb-212; (*b*) activity due to Pb-212; (*c*) decay of pure Bi-212 fraction; (*d*) Bi-212 activity growing from an initially pure Pb-212 fraction; (*e*) total Bi-212 activity in Pb-212 + Bi-212 fractions

The authors wish to express their sincere thanks to Dr. V. T. Athavale, Head, Analytical Division, AEET for his keen interest in the work.

Literature Cited

(1) Cook, G. B., and Duncan, J. F., "Modern Radiochemical Practice," Oxford, 1958.
(2) Willard, H. H., Meritt, L. L., and Dean, J. A., "Instrumental Methods of Analysis," Van Nostrand Co., Inc., New York, 1958.
(3) Kruger, P., and Coryell, C. D., J. Chem. Educ., **32**, 280 (1955).
(4) Hayes, R. L., and Butler, W. R., Jr., *ibid.*, **37**, 590 (1960).
(5) Dillard, C. R., and Morton, L., *ibid.*, **35**, 238 (1958).
(6) Von Gunten, H. R., Buser, W., and Houtermans, F. G., Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, 1958, p. 250, Vol. 2, p. 239, United Nations, New York.

Table I. Genetically Related Pairs of Radionuclides Used for Growth Decay Study

Genetically related pair	Source of availability	Half life of the parent nucleide	Half life of the daughter nucleide	Time of max. activity T_{max}'[a]
1. $^{140}Ba - ^{140}La$	^{235}U fiss. prod.	12.8 days	40.2 hrs.	5.8 days
2. $^{90}Sr - ^{90}Y$	^{235}U fiss. prod.	28 yrs.	64.0 hrs.	26.6 days
3. RaD – RaE ($^{210}Pb - ^{210}Bi$)	Rn needles	22 yrs.	5.0 days	50 days
4. UI – UXI ($^{238}U - ^{234}Th$)	Pure U salt	4.5×10^9 yrs.	24.1 days	241 days
5. $^{144}Ce - ^{144}Pr$	^{235}U fiss. prod.	285 days	17.0 mins.	2.8 hrs.
6. $^{137}Cs - ^{137m}Ba$	^{235}U fiss. prod.	30 yrs.	2.63 mins.	26.3 mins.
7. ThB – ThC	$Th(NO_3)_4$	10.6 hrs.	60.5 mins.	3.76 hrs.

[a] T'_{max} has been taken as ten times the daughter half life in the case of secular equilibria.

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Method for Determining Order of a Reaction

Frequently the properties of a kinetic system are such that the degree of advancement of the reaction can be determined only once for any given sample; i.e., neither periodic determinations of a characteristic property nor periodic removal of aliquots for subsequent analysis is feasible. When this situation is encountered in reactions with moderate rates, one usually runs parallel samples on which determinations are made at different times following inception of the process. For very fast reactions, however, this approach becomes complicated and is often impossible, while for very slow ones (e.g., geochemical processes) it is also often impossible. In the study of very fast processes, numerous ingenious stratagems[1] (e.g., the various flow reactors or the application of relaxation methods) have been devised to permit the interpretation of rate data. However, most of these methods suffer either from the disadvantage of extreme waste in the consumption of materials during the experiments or from the high cost of the requisite apparatus.

Since a general method is needed for the treatment of practical data dealing with both extremes of rate phenomena, the present paper will attempt to lay a groundwork for that purpose. The basic procedure used is a substitution process which expresses the various rate laws in terms of one initial concentration only. Remaining concentration factors are reduced to dimensionless parameters expressing the ratios of initial concentrations and a reaction index which is unity at the beginning of a process and decreases toward zero as the reaction progresses.[2]

Notation

k: specific rate constant
C_a: instantaneous concentration of dominant reagent, A
C_b, C_c: instantaneous concentrations of minor reagents
C_a^0, C_b^0, C_c^0: concentrations of above reagents at zero time
t: time measured from inception of reaction
t_i: time corresponding to the reaction index, i
$i = C_a/C_a^0$: index of reaction
n: ratio of initial concentrations, C_a^0/C_b^0
m: ratio of initial concentrations, C_a^0/C_c^0
x: advancement of reaction, $C_a^0 - C_a$
r: reaction order

This work was supported by the National Science Foundation.

[1] Eigen, M., and Johnson, J. S., *Ann. Revs. Phys. Chem.*, 11, 307–34 (1960).

[2] Although this is commonly done with zeroth order reactions and has been done occasionally with first order ones (e.g., Brown, H. C., and Fletcher, E. A., *J. Am. Chem. Soc.*, 73, 2808 (1951)) as well as in several problems conducted in our laboratory (viz. Zimmerman, H. K., et al., *Ann.*, 628, 37 (1959); 655, 48, 54 (1962)), its general utility appears not to have been fully appreciated and applied.

Zeroth Order Reactions

The integrated rate law for a zeroth order reaction, the rate of which is independent of concentration of reagent, may be written as

$$k = (C_a^0 - C_a)/t = C_a^0(1 - i)/t_i \qquad (1)$$

The specific rate may be determined directly from equation (1). Alternatively, a plot of C_a^0 against t_i is linear with a slope such that $k = (1\text{-}i)$ (slope). (The reaction index most commonly used is $i = 1/2$, in which case $k = 1/2$ (slope).) Yet another method of data treatment which may be drawn from equation (1) is a plot of i against t_i to yield a straight line originating at $i = 1$ and having a slope of $-k/C_a^0$.

First Order Reactions

The integrated rate law for a first order reaction may be readily written in terms of the reaction index as follows:

$$k = \frac{1}{t} \ln \frac{C_a^0}{C_a} = -\frac{1}{t_i} \ln i = \frac{-2.303}{t_i} \log i \qquad (2)$$

equation (2), which implies that t_i is independent of the initial concentration of reagent, permits direct calculation of the specific rate; and for the so-called "half-life" it reduces to the familiar relation, $k = 0.693/t_{1/2}$. When t_i values are known for a variety of different reaction indexes, as in the method of parallel rate runs, a plot of $\log i$ against t_i is linear with its intercept at the origin and a slope of $-k/2.303$.

Second Order Reactions

Among second order reactions, in which the rate of reaction is proportional to two concentrations, two experimental cases are usually distinguished according to whether the initial concentrations of reagents are equal or different from each other.

Case I, $C_a = C_b$. When the initial concentrations are equal, the integrated rate law yields

$$k = \frac{C_a^0 - C_a}{C_a C_a^0 t} = \frac{1 - i}{i t_i C_a^0} \qquad (3)$$

The specific rate may be computed directly from equation (3) through a knowledge of the t_i corresponding to any reaction index. When the half-time is used, equation (3) reduces to the familiar $k = 1/C_a^0 t_{1/2}$. When t_i values are known for a particular reaction index employing a series of different initial concentrations, it follows from equation (3) that a plot of $1/C_a^0$ against t_i will be linear with the intercept at the origin and a slope of $ki/(1 - i)$. On the other hand, when one plots the function $(1 - i)/i$ against t_i for different

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reaction indexes obtained from a fixed initial concentration, a straight line from the origin is obtained with a slope equal to kC_a^0.

Case II, $C_a \neq C_b$. In the general case of a second order rate process, the concentrations of the two reagents are unequal. One may then write the rate law in terms of the dominant reactant and the advancement of the reaction in the following manner:

$$\frac{dx}{dt} = k(C_a^0 - x)\left[\frac{C_a^0}{n} - x\right] \tag{4}$$

It should be noted that the notation for the species A and B is selected so that $n > 1$. Integration of equation (4) between limits leads to

$$kt = \frac{n}{(n-1)C_a^0} \ln \frac{C_a^0 - x}{C_a^0 - nx} \tag{5}$$

Introduction of the reaction index, in terms of which

$$x = (1\text{-}i)\, C^0{}_a$$

yields

$$k = \frac{n}{(n-1)C_a^0 t_i} \ln \frac{i}{1 + (i-1)n} \tag{6}$$

from which the specific rate may be directly obtained. From this relation it may also be shown that, at a constant reaction index and ratio of initial concentrations, a plot of t_i against $1/C_a^0$ is linear from the origin with a slope given by the expression,

$$\frac{2.303n}{(n-1)k} \log \frac{i}{1 + (i-1)n}$$

Similarly, if both of the initial concentrations are held constant, the plot of t_i against the function,

$$\log \frac{i}{1 + (i-1)n}$$

is linear from the origin with a slope given by

$$\frac{2.303n}{(n-1)kC_a^0}$$

In considering the application of equation (6), it must be remembered that the limitation that $n > 1$ imposes certain restrictions. Specifically, examination of the logarithmic argument in equation (6) reveals a singularity when $i = 1 - 1/n$, which follows from the definition of n. Thus equation (6) becomes physically meaningless for $i \leq 1 - 1/n$, since for such values the advancement of reaction would exceed C_b^0. Within this limitation, however, equation (6) shows that the half-life concept (i.e., correspondence of t_i to a given index) is just as valid for unequal concentrations as it is for equal ones.

Third Order Reactions

Normally three types of composition circumstances may be envisioned with third order reactions. When the reaction index and the dimensionless composition parameters are employed in a manner analogous to that already indicated, the resulting integrated rate laws are found in the form summarized below:

Case I, $C_a = C_b = C_c$.

$$k = \frac{1}{2t_i(C_a^0)^2}\left[\frac{1 - i^2}{i^2}\right] \tag{7}$$

Case IIa $C_a = C_b \neq C_c$

$$k = \frac{n^2}{(1-n)^2 (C_a^0)^2 t_i}\left[\frac{(1-i)(1-n)}{ni} + \ln \frac{i}{1 - n(1-i)}\right] \tag{8}$$

Case IIb, $C_a \equiv C_c \neq C_b$

$$k = \frac{n^2}{(2-n)^2 (C_a^0)^2 t_i}\left[\frac{2(1-i)(2-n)}{n(2i-1)} + \ln \frac{2i-1}{1 - n(1-i)}\right] \tag{9}$$

Case III, $C_a \neq C_b \neq C_c$

$$k = \frac{mn}{(C_a^0)^2 \left\{\left[\frac{m}{n} - 1\right]\left[1 - mn - \left(\frac{m}{n} - 1\right)n\right]\right\}} \times \left\{\left[\frac{m}{n} - 1\right] \ln (ni^2 - i(n-1)) + \frac{m}{n}(n-1) \ln \left[\frac{1 - (1-i)m}{1 - (1-i)n}\right]\right\} \tag{10}$$

In each of these special cases, the specific rate may, of course, be ascertained directly from computation based on one of the equations (7) through (10). Graphically, a plot of t_i against either $1/C_a^0)^2$ (at constant index) or the function of i shown in brackets in each case (at constant initial composition) gives a linear relation in which the slope is inversely proportional to the specific rate. When $i = 1/2$, equation (7) reduces to the familiar "half-life" expression for a third order process. In equation (8) through (10) the same principle is valid subject to the limitation that $i \geq 1 - 1/n$, since these three expressions possess the same type of singularity already noted for second order reactions. Moreover, in equation (8) the numerator of the logarithmic argument shows that indexes smaller than $1/2$ are meaningless even when n lies between 1 and 2. In equation (10) there are two formal singularities, namely at $i = 1 - 1/n$ and at $i = 1 - 1/m$. However, since $m > n$, the latter controls.

The General Case

One may visualize a rate law of the rth order, in which it may be shown that the integrated rate law is

$$k = \frac{1}{(r-1)(C_a^0)^{r-1} t_i}\left[\frac{1 - i^{r-1}}{i^{r-1}}\right] \tag{11}$$

The same methods of using the equation to determine specific rates that have already been mentioned also apply here, and when the reaction index is $1/2$, the usual "half-life" relation emerges.

As a result of the treatment developed here, it is seen that the integrated rate laws may be expressed in a general sense in terms of dimensionless concentration terms except for the concentration of the major reagent. Not only does this procedure clarify the dimensional relationships involved, but it also emphasizes the generality of the reaction index as a concept common to all simple rate laws.

In consequence of this generalization, these conclusions follow:

(1) The applicability of the "half-life" concept to cases of reaction orders greater than unity is seen to be valid within the limits of the condition, $1 > i > 1 - 1/n'$ (where n' is the ratio of initial concentration of the most plentiful reagent to that of the least plentiful one), even for the general situation wherein the initial concentrations of the reagents are *unequal*.

(2) From the first conclusion, it follows that it is possible to determine the specific rate of any reaction

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of simple order from a knowledge of reaction index at a single point in time together with a knowledge of the reagent concentrations at the beginning of the reaction.[2]

(3) Even in the most general situation, the order of a simple reaction conforms to the condition[3] that, for any given permitted reaction index and initial ratio of reactants, the product, $t_i(C_a^0)^{r-1}$, is a constant. From this fact, it may be shown that the order is given by

$$r = \frac{K + \log(C_a^0/t_i)}{\log C_a^0} \qquad (12)$$

where the constant, K follows from the appropriate plot of t_i against $1/(C_a^0)^{r-1}$.

[3] This condition is well known in testing reaction orders by the "half-life" method, *viz.* LAIDLER, K. J., "Chemical Kinetics," McGraw-Hill, New York, 1950, p. 14.

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A Qualitative Approach to the Study of Complex NMR Spectra

Roberts (*1*) recently has described the fundamentals of NMR spectroscopy in a manner that is useful for teaching the subject to undergraduates. When presented in this way we find, however, that it leaves a student lacking in the appreciation for more complex spectra, which are by far the more common forms encountered in practice. We have found that a useful extension to Roberts description of NMR is the application of the experimental approach to changing a simple spectrum into a more complex spectrum. This procedure makes it unnecessary to consider at this stage a mathematical description of complex spectra and gives a student a feeling for such spectra which, it is hoped, will spur him to further study of the subject.

Nuclear magnetic resonance spectra are simple, i.e., can be described by first-order theory, when the chemical shift (Δ in cps) between two signals is much greater than the spin-coupling constant (J in cps). This is the case in ethyl ether (see Fig. 1) where Δ is 135 cps and J is 7.0 cps and for which we have a clearly defined triplet and quartet as predicted by the first-order methods described by Roberts (*1*). A spectrum is complex when the values of Δ and J are nearly equal. For such a situation first-order theory does not predict the spectrum and in general there are more lines than predicted by the first-order theory. Such spectra are discussed thoroughly in texts and reviews (*2–4*) and the line structure of most spectra can be calculated if sufficient variables are known.

Simple spectra can be made complex in two ways. First, since Δ varies directly with the applied field H_0 used to obtain resonance and since J is field independent, a decrease in H_0 will reduce Δ and can cause the ratio of J/Δ to approach 1. For example a spectrum which has a value of J/Δ of 0.2 at 60Mc will closely resemble the first-order spectrum. At 16Mc, however, where J/Δ is 0.75 many second-order effects will have appeared. This can be illustrated by the spectrum of ethyl alcohol for which Arnold (*5*) reports second-order splitting for the CH_3 of ethyl alcohol at 30Mc. This splitting is less complex at 60Mc. Most laboratories are not equipped for determining spectra

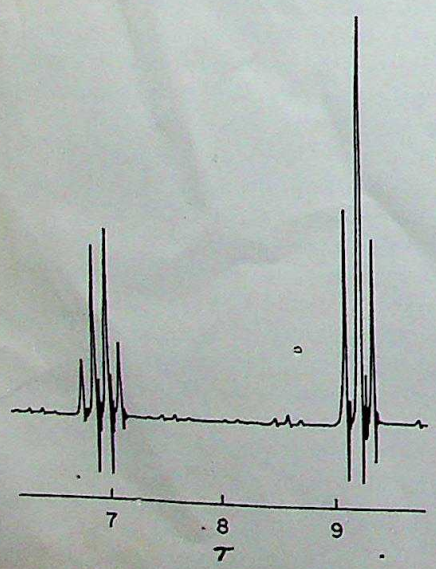

Figure 1. Ethyl ether.

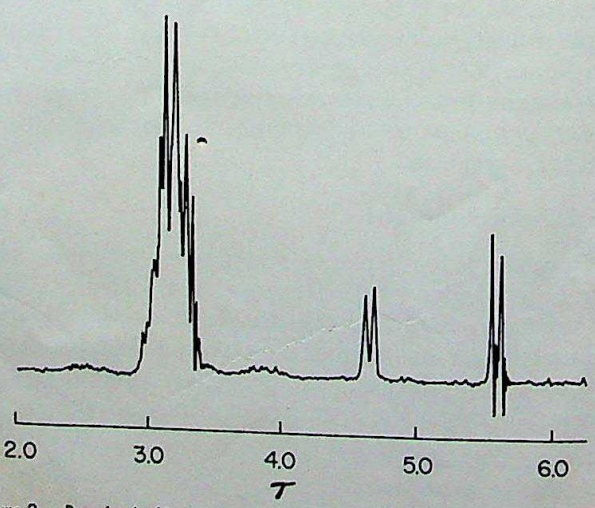

Figure 2. Benzhydrol in acetone

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at a number of field strengths and thus this method is little used.

Second, Δ can often be changed by changes in solvent. Some signals are particularly sensitive to concentration and to the nature of the solvent. This is the case with the OH signal of an alcohol which can often be moved from the 4τ region to the 9τ region by solvent changes. If the OH is coupled to a proton which is not affected by solvent and which lies in the 4–9τ region, then Δ can be varied to give a large variation in the value of J/Δ. In this way many simple spectra can be made complex. This approach was first used in the study of the coupling of the OH signal of benzyl alcohol with its CH_2 component by Corio, Rutledge, and Zimmerman (*6*).

The advantage of studying complex spectra by transforming simple spectra into complex spectra is that J is not affected by the change and thus J can be found from the simple spectra and used in the study of the complex spectra (the J for an alcohol does depend on its environment due to the orientation of the OH function but such changes on dilution are assumed small). A second advantage is that several variations of the one type of coupling are available from the one sample.

In order to describe more fully the use of solvent shifts in the study of complex spectra it is necessary first to discuss in general terms the factors influencing the spectra of alcohols. In carbon tetrachloride or chloroform the OH of alcohols is usually not split, although such splitting is expected due to the coupling between the OH and adjacent CH. Thus of some 25 spectra of alcohols (7% solutions in deuterochloroform) displayed in the Varian Catalog (*7*) only three show this coupling. On the other hand, as the undiluted liquid or in solvents like acetone or dimethyl sulfoxide it is quite common to observe the CH to OH coupling.

The absence of splitting of the OH peak has been attributed to an exchange process (*8*) in which the proton of one molecule transfers to a second at a rate that is sufficiently fast that the lifetime of a proton on any molecule is much less than the lifetime of 10^{-2}–10^{-3} sec required for NMR to observe a single state. The result is that the proton of the OH sees a number of environments which are averaged in the measurement to give a single peak rather than a split peak. The exchange rate is catalyzed by both acids and bases and thus in the presence of such catalysts all alcohols show no splitting for the OH.

The use of acetone and dimethyl sulfoxide as solvents to permit the observation of spin-spin splitting of the OH peak can be demonstrated for methanol and 2,2,2 trifluoroethanol. Both of these alcohols do not show splitting in the pure state even with rigorous purification. In the solvents acetone (*9*, *10*) and dimethyl sulfoxide (*10*, *11*), however, splitting of the OH is observed. It has been proposed that hydrogen bonding of the alcohol to the solvent slows the rate of proton exchange to permit observation of the splitting (*9*).

The second feature of the spectra of alcohols which is important to our discussion is hydrogen bonding. Alcohols undiluted or in solution hydrogen bond to form dimers, trimers, and polymers. Each form is expected to give its own NMR signal, but because of the rapid change of the state of agglomeration in the time required for NMR measurement, the OH protons are found in a number of states of agglomeration and the chemical shift position of the OH is a weighted average for these species (*12*). Dilution in a solvent favors formation of the species of lower states of agglomeration and the chemical shift will approach that of the monomer. This corresponds in a shift from low field to high field. For ethanol dilution with carbon tetrachloride shifts the OH signal from 5 to 9.5 τ (*13*).

Dilution shifts of this magnitude do not always occur. For example benzhydrol in acetone shows little dilution shift. This is probably because under these conditions benzhydrol already exists as a monomer hydrogen-bonded to solvent. A shift of the OH signal can still be

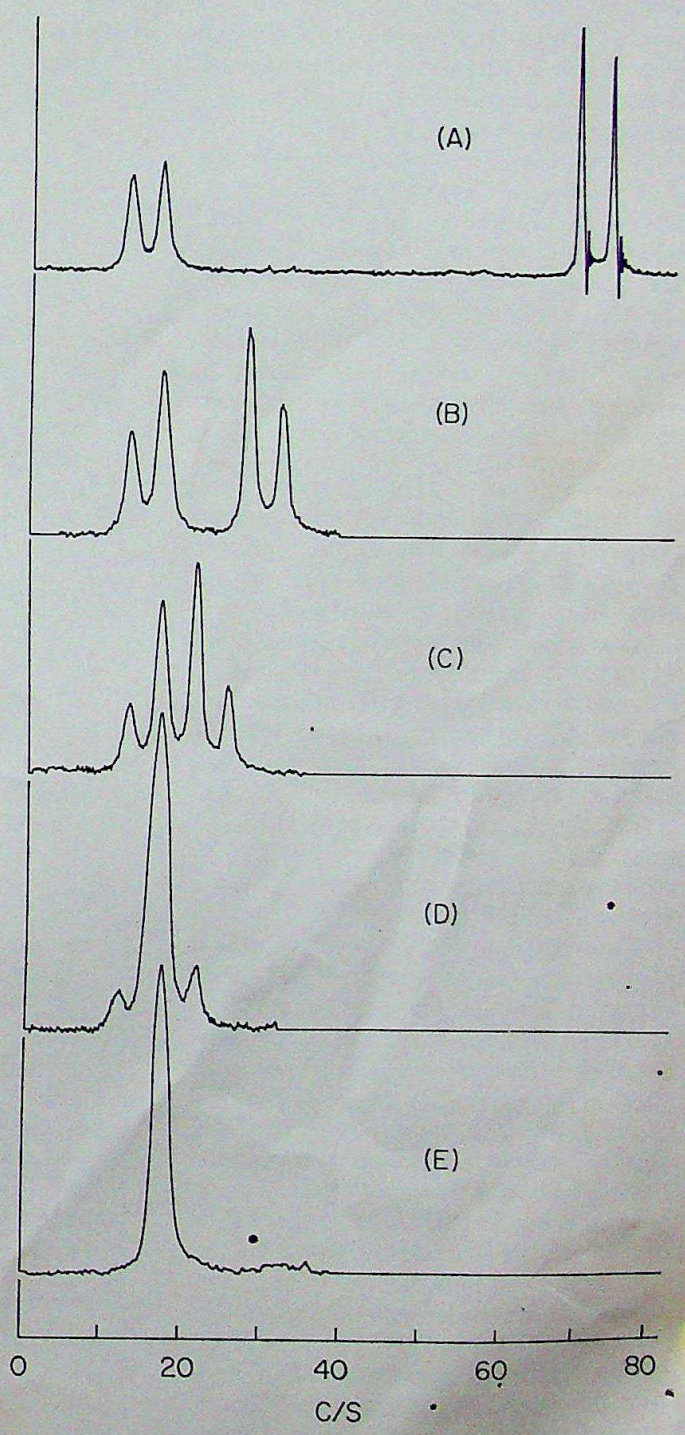

Figure 3. A-E-addition of portions of ethanol to a solution of benzhydrol in acetone for which J = 4 cps. J/Δ for A = 0.071, B = 0.28, C = 0.54 and D = 0.95.

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produced, however, by addition of other solvents with different hydrogen bonding properties. Thus the OH of benzhydrol in acetone is shifted to lower field by the addition of either ethanol or dimethyl sulfoxide.

On the basis of the above discussion it can be seen that the OH signal can be shifted quite simply and thus values of J/Δ for many types of spectra can be obtained to provide an experimental means for converting simple spectra into more complex spectra. In the following section we will describe the application of some of these principles.

The simplest first-order spectrum showing splitting is that in which a single proton is coupled with a second proton such that J/Δ is small. This is an AX system (*14*) and leads to a pair of doublets and is illustrated by benzhydrol in acetone where J is 4 cps and J/Δ is 0.071 (see Fig. 2). Addition of ethanol moves the OH doublet down field toward the CH doublet as shown in Figure 3 and changes the AX system into an AB system. The OH triplet of the ethanol is not shown but appears separately at higher field.

It is immediately apparent that as J/Δ increases toward one the outer signals of the pair of doublets weaken compared to the inner signals. Finally the transitions responsible for the outer signals become forbidden and the inner signals coalesce. Theoretical treatment (*15*) of the AB system tells us that J and Δ are related to the spacings of the signals according to the equation

$$C = {}^1/_2(\Delta^2 + J^2)^{1/2}$$

where $2C - J$ is equal to the spacing between the two inner signals. Since J is known from the first-order spectrum Δ can readily be calculated.

A more complex system is illustrated by benzyl alcohol (see Fig. 4) in which the OH and adjacent CH_2 make up a simple AX_2 system. This leads to a doublet for the CH_2 and a triplet for the OH for which J is 5.6 cps and J/Δ is 0.10. Addition of acetone causes a high-field dilution shift of the OH signal changing the AX_2 system into an AB_2 system. (See Fig. 5.)

These spectra clearly show how complex spectra can have more lines than expected for the corresponding first-order system. For the AB_2 system there are theoretically eight lines and these are numbered in Figure 5. Lines 5 and 6 are not resolved in this instance. Theory predicts these eight lines plus an additional line of low transition probability and values of Δ and J can be calculated from them. The separation between line 3 and the midpoint between lines 5 and 7 gives the value of Δ. Roberts (*16*) clearly illustrates the relation between J/Δ and the line positions by graphical means. In our case J is known from the first-order spectrum, but if it were not known it could be obtained from the graph.

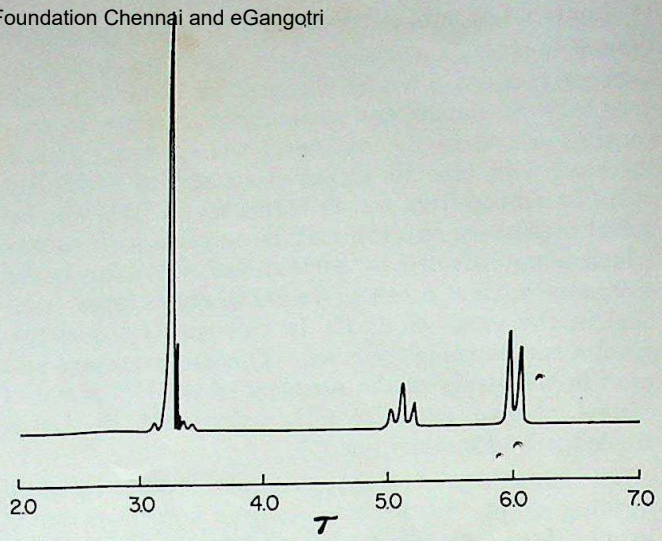

Figure 4. Benzyl alcohol.

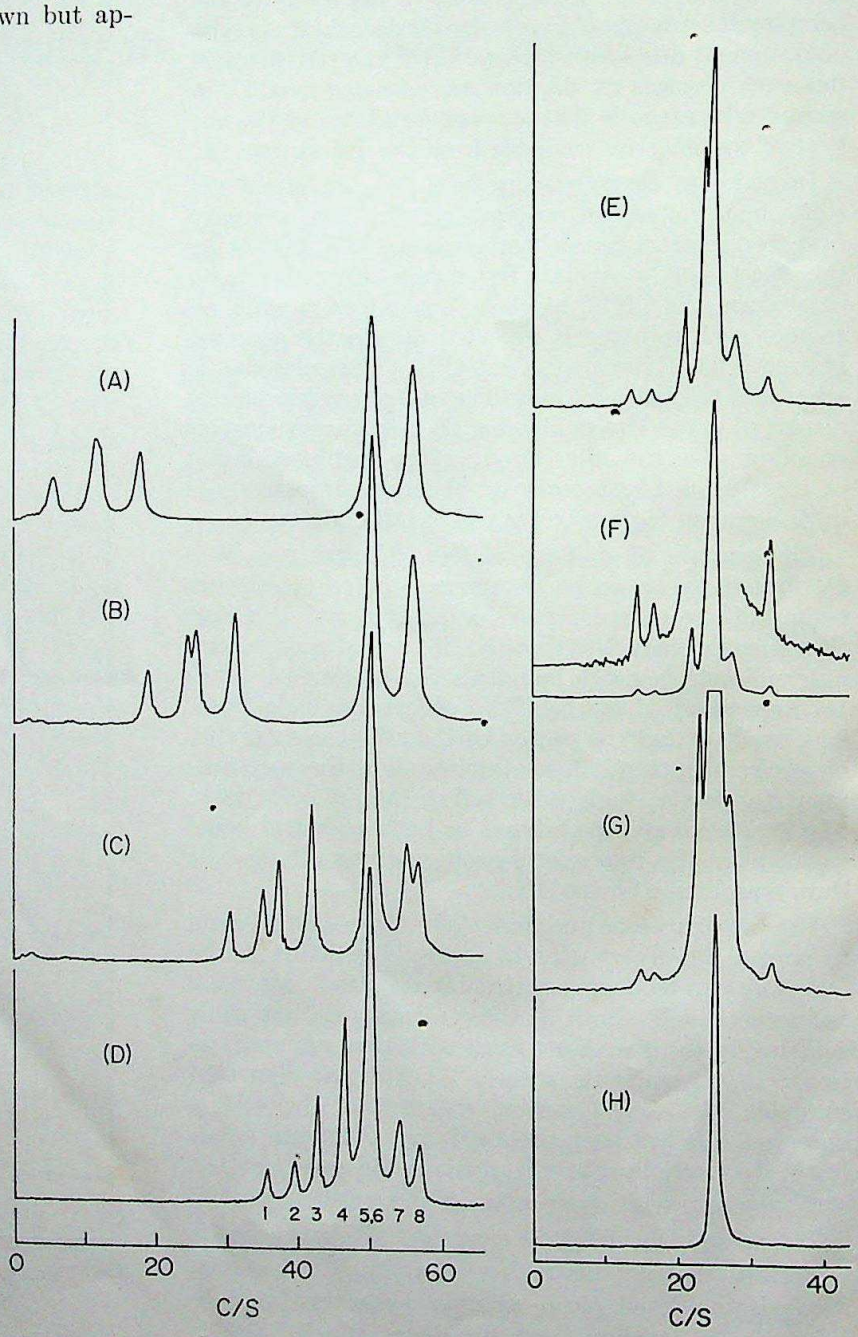

Figure 5. A-H-Addition of portions of acetone to benzyl alcohol for which J = 5.6 cps. Per cent by wt. of benzyl alcohol and J/Δ for A = 78, 0.14, B = 67, 0.21, C = 55, 0.37, D = 51, 0.60, E = 45, 1, F = 43, 1.3, G = 42, 1.9 and H = 40

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From these two examples it can be seen that many spectra can be created by use of the wide variety of alcohols available. For example methanol gives an AB_3 system (*11*), isobutyl alcohol gives the AB_2 part of an AB_2X system and 2,2,2-trifluoroethanol gives the AB_2 part of an AB_2X_3 system.

The application of solvent shifts in studying spectra is not restricted to alcohols, as has been shown by Schaefer and Schneider in their excellent study on vinyl bromide (*17*). They found that different solvents could change the relative positions of the geminal hydrogens from −4 to +9 cps. The solvents used were benzene, *n*-hexane and acetone.

We have found that a great deal of information can be obtained from the spectra of alcohols in general when fullest use is made of the solvent effects. Citronellol shows a single peak for the OH when undiluted or in carbon tetrachloride. In dimethyl sulfoxide the OH is a triplet at 5.81 τ clearly indicating this to be a primary alcohol (see Fig. 6). Changes in the spectrum between the undiluted sample and the sample in dimethyl sulfoxide permits easy assignment of the peak at 6.58 τ to the CH_2 coupled to the OH. The triplet at 4.96 τ is due to the vinyl CH.

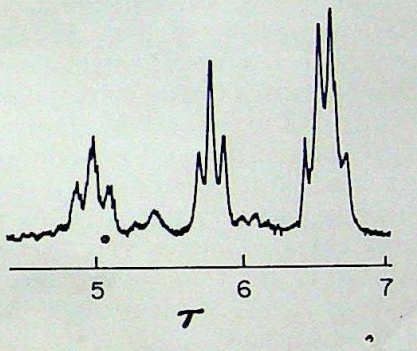
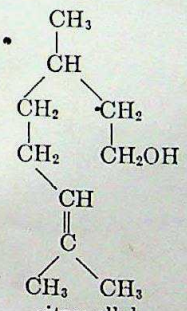
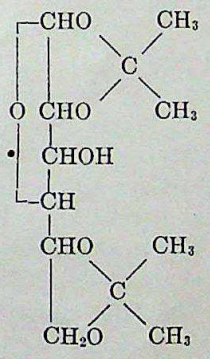


Figure 6. Citronellol in dimethyl sulfoxide.



citronellol



diacetone glucose

Diacetone glucose in acetone has its OH peak hidden among other CH peaks. On the addition of water the OH doublet becomes clearly identifiable as it shifts to lower field (see Fig. 7). The doublet structure for the OH proves the secondary nature of this alcohol. Assignments to all hydrogens in a series of carbohydrates has been made using these and related methods (*18*).

The spectra reported herein were obtained on a Varian Associates A-60 instrument. We wish to thank Mrs. E. Brion for determining most of the spectra.

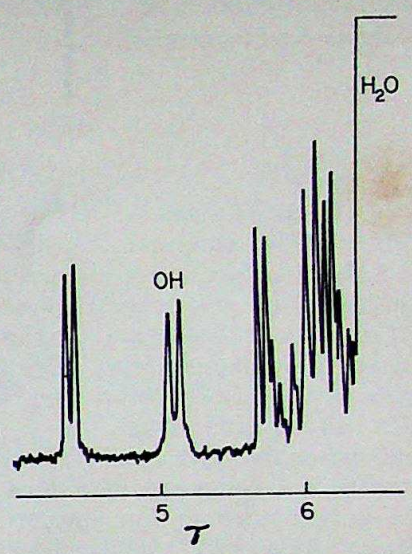


Figure 7. Diacetone glucose in acetone with water added.

Literature Cited

(1) Roberts, J. D., J. Chem. Educ., **38**, 581 (1961).
(2) Roberts, J. D., "An Introduction to the Analysis of Spin-Spin Splitting in High-Resolution Nuclear Magnetic Resonance Spectra," W. A. Benjamin, Inc., New York, 1961.
(3) Pople, J. A., Schneider, W. G., and Bernstein, H. J., "High-resolution Nuclear Magnetic Resonance," McGraw-Hill Book Company, Inc., New York, 1959.
(4) Corio, P. L., *Chem. Revs.*, **60**, 363 (1960).
(5) Arnold, J. T., *Phys. Rev.*, **102**, 136 (1956).
(6) Corio, P. L., Rutledge, R. L., and Zimmerman, J. R., *J. Molecular Spectroscopy*, **3**, 592 (1959).
(7) Bhacca, N. S., Johnson, L. F., and Schoolery, J. N., "Varian High-Resolution NMR Spectra Catalog," Varian Associates, Palo Alto, Calif., 1962.
(8) Pople, J. A., et al., *op. cit.*, p. 417.
(9) Corio, P. L., Rutledge, R. L., and Zimmerman, J. R., *J. Am. Chem. Soc.*, **80**, 3163 (1958).
(10) Unpublished results by Mocek, M. M.
(11) Kivelson, D., and Kivelson, M. G., *J. Molecular Spectroscopy*, **2**, 518 (1958).
(12) Pople, J. A., et al., *op. cit.*, chap. 15.
(13) Cohen, A. D., and Reid, C., *J. Chem. Phys.*, **25**, 790 (1956).
(14) Jackman, L. M., "Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry," Pergamon Press, New York, 1959, p. 89.
(15) Pople, J. A., et al., *op. cit.*, p. 121.
(16) Roberts, J. D., "Analysis of Spin-Spin Splitting," p. 70.
(17) Schaefer, J., and Schneider, W. G., *Can. J. Chem.*, **38**, 2066 (1960).
(18) Abraham, R. J., Hall, L. D., Hough L., and McLauchlan, K. A., *J. Chem. Soc.*, 1962, 3699.

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Simple Preparations of Phosphors

In recent years the volume of literature pertaining to the solid state has been growing larger and larger. About a third of the current physical research is in this field. Phosphor chemistry offers a simple and colorful introduction to this phase of chemistry at the undergraduate level. The preparation of some phosphors outlined below may be used as experiments in an inorganic course.

Phosphors, materials which exhibit fluorescence and phosphorescence, are composed of a host crystal or matrix, and an activator or luminescence-promoting material in small quantities. A flux, usually an alkali or alkaline earth halide, may or may not be used to aid in the production of the phosphor. It provides a medium for the transport of materials, increases surface reactivity and increases atomic mobility to facilitate crystal growth. Details of crystal imperfections, color centers, and the mechanism of phosphorescence are beyond the scope of this paper, but may be found in excellent treatises on the subjects.

A muffle furnace capable of maintaining up to 900°C is needed for firing the materials. Silica crucibles with covers serve as excellent containers for the process. An ultraviolet source[1] emitting strongly at 3650Å is used to excite the phosphors to luminescence. If a dark room is not available, a partially closed wooden box painted black may be used. Purity of materials and precautions to prevent contamination in handling are very important. As little as 3 to 5 ppm nickel will cause zinc sulfide phosphors to become inert. For best results, use luminescent grade ZnS and CdS.

Experiments

Preparation of a Phosphor at Room Temperature.[2] KCl crystals are placed within 1 cm of $SbCl_3$ under a 3650Å UV light source in a dark room or a dark box. The initially nonluminescent KCl crystals will begin to show a yellow luminescence as the molecules of $SbCl_3$ volatilize and come in contact with the KCl. Grinding the KCl crystals with $SbCl_3$ in a mortar will accelerate the process.

Effect of Various Activators

ZnS Activated by Ag. Add 20 mg of $AgNO_3$ to a slurry of 100 g ZnS in 25 ml of water. Stir thoroughly and evaporate to dryness at 120°C. Intimately mix 2 g of finely divided NaCl with the ZnS. Transfer to a silica crucible, cover and place in a furnace at 900°C. Fire at this temperature for two hours and while still covered remove crucible from the furnace to cool to room temperature before examining under UV. A blue luminescence will be observed.

ZnS Activated by Mn. Repeat except that 4.5 g $MnCl_2$ is substituted for $AgNO_3$. A yellow luminescence will be observed.

ZnS Activated by Cu. Repeat except that 40 mg of $CuSO_4 \cdot 5H_2O$ is substituted for $AgNO_3$. A green luminescence with a longer period of emission after removal from source of excitation (afterglow) than that of ZnS:Ag or ZnS:Mn will be observed.

Zinc sulfide and cadmium sulfide form solid solutions throughout the entire concentration range. When these are used as host crystals with silver as activator, the spectrum changes progressively from the blue region to infrared as the CdS content increases from 0 to 100%. This can be demonstrated by performing the following experiment.

Add 61 g ZnS and 39 g CdS to 25 ml of $AgNO_3$ solution containing 8 mg $AgNO_3$, and evaporate to dryness at 120°C. Intimately mix 2 g of finely divided NaCl with the above mixture. Transfer to a silica crucible, cover and place in a furnace at 800°C. Fire for 2 hours and while still covered remove from furnace to cool to room temperature. This phosphor emits most strongly at 5200Å.

Repeat except that 40 g of ZnS and 60 g CdS are used. The peak emission occurs at 5740Å.

Repeat except that 32 g of ZnS and 68 g of CdS are used. The peak emission occurs at 6100Å.

[1] Lite-Mite made by Stocker and Yale, Inc., Marblehead, Mass., is convenient.

[2] Leverenz, H. W., "Luminescence of Solids," John Wiley and Sons, Inc., New York, 1950.

Bibliography

Garlick, G. F. J., "Luminescent Materials," Oxford University Press, London, 1949.
Gray, T. J., "The Defect Solid State," Interscience Publishers, Inc., New York, 1957.
Kroger, F. A., "Some Aspects of the Luminescence of Solids," Elsevier Publishing Co., Amsterdam, Holland, 1948.
Leverenz, H. W., "Luminescence of Solids," John Wiley and Sons, Inc., New York, 1950.
Pringsheim, P., "Fluorescence and Phosphorescence," Interscience Publishers, Inc., New York, 1949.
Seitz, F., "Imperfection in Nearly Perfect Crystals," John Wiley and Sons, Inc., New York, 1952, pp. 3–76.
Seitz, F., and Turnbull, D., "Solid State Physics," Academic Press, Inc., New York, 1957, Vol. 5; 1959, Vol. 9.

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An Experiment with Galvanic Cells

For the general chemistry laboratory

The inclusion of an experiment on galvanic cells in the general chemistry course is somewhat inconvenient, particularly at institutions with very large enrollments in the beginning course. Perusal of recent editions of general chemistry laboratory manuals reveals that four out of fifteen do not include any experiment on galvanic cells; the others use a "conventional" set-up involving a voltmeter and a U-tube salt bridge or a porous barrier. Only one manual[1] suggests a means other than a meter for detecting the direction of electron flow through the external circuit. For very large enrollments, even with students working in pairs, the cost of voltmeters and of the relatively large amounts of chemicals required is considerable. Moreover, among beginning students, the casualty rate of U-tube salt bridges is high. Porous cups or H-tube cells with sintered glass barriers[2] are more suitable for small classes. Some electrochemical experiments for freshmen have been described by Gorman.[3] These are done by students working in groups of two or three.

The galvanic cell design described below has been used by first semester general chemistry classes of approximately 1000 students working individually. It requires no special apparatus, and because the quantities of materials used per student are small, the total cost is relatively low. Each student constructs a workable cell using metal-metal ion couples designated by the instructor, determines the direction of electron flow in the external circuit, and compares the relative electromotive potentials of several redox couples.

To introduce the experiment on galvanic cells, the concepts of oxidation-reduction couples, half-cells, and electrode reactions in both galvanic and electrolytic cells are reviewed.[4,5] It is stated that a complete galvanic cell circuit consists of two half-cells, an external conductor, and an electrolytic contact between the half-cells. The electrolytic contact is usually a salt solution which separates the two half-cells while providing ions to conduct a current between them. Consequently it is termed a *salt bridge*. The form and constitution of the salt bridge is a matter of practical convenience.

The electrolysis of water is discussed. It is pointed out that at the electrode of the electrolytic cell which supplies electrons from the external circuit there is an increase in the concentration of hydroxide ions; while at the electrode from which electrons are drawn into the external circuit, there is an increase in the concentration of hydrogen ions. Thus by using the galvanic cell to electrolyze water containing a suitable indicator, the direction of electron flow from the galvanic cell may be deduced.

The Experiment

The galvanic cell consists of three parts: a copper-copper ion reference half-cell, a salt bridge, and a metal-metal ion half-cell. Construction of each part is described below.

Copper Reference Half-Cell. About 4 in. of a 10-in. piece of fine copper wire (B & S gauge #24) is made into a coil by winding onto a small nail or a straightened paper clip. The tube containing the salt bridge is filled with 1.0 *M* $CuSO_4$ by means of a capillary pipet, and the copper coil is inserted. See Figure 1*a*. The cell is then assembled as is shown in Figure 1*b*.

Salt Bridge. A 6-in. length of 6-mm od soft glass tubing is fire-polished on one end, and the other end is heated and rotated in the flame until it contracts to about one-half its original diameter. When cool the tube is inserted into a #1 one-hole rubber stopper with the constricted end down, and a very small wad of cotton (or a few strands of fine glass wool) is inserted

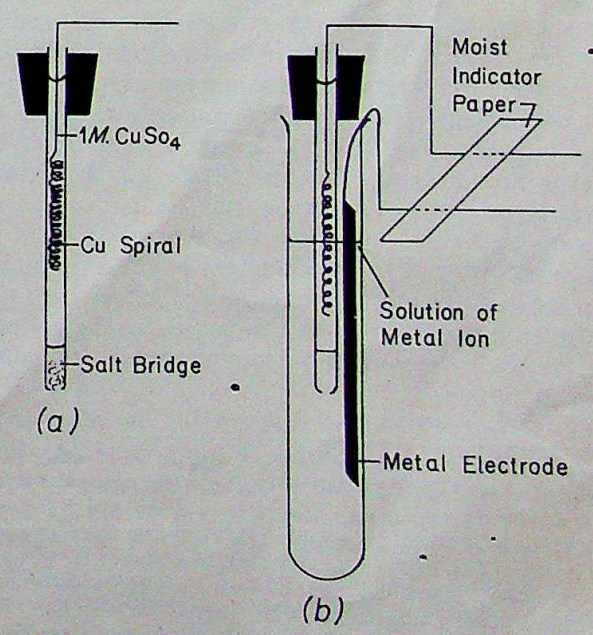

Figure 1. Cu, Cu^{++}, half-cell, (a) and assembled galvanic cell, (b).

[1] Laubengayer, A. W., "Experiments and Problems in General Chemistry," Rinehart and Co., New York, 1959, Expt. 34.
[2] Andrews, D. H., and Kokes, R. J., "Laboratory Manual for Fundamental Chemistry," John Wiley and Sons, New York, 1962, chap. 12.
[3] Gorman, J., J. Chem. Educ., 34, 409 (1957).
[4] Latimer, W. M., "Oxidation Potentials," 2nd ed., Prentice-Hall, New York, 1952.
[5] Daniels, F., and Alberty, R. A., "Physical Chemistry," 2nd. ed., John Wiley and Sons, New York, 1961, Chap. 14.

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down the tube to the constriction. The constricted end of the tube is dipped into a hot $NaNO_3$-agar solution (prepared by the instructor)[6] so that the liquid rises just above the cotton. The function of the cotton is merely to give the agar gel mechanical strength. (See Figure 1*a*.) The tube is removed and set aside about 10 min.

Metal-Metal Ion Half-Cell. Each student is assigned a specific metal in the form of a strip or a rod. After the surface of the metal is cleaned with sandpaper *or* treated according to the detailed instructions for specific metals (given below), a 6-in. piece of copper wire is attached.

Twenty ml of 1.0 *M* solution of the appropriate metal ion is put into a 6-in. (18 × 150 mm) test tube, the metal electrode is inserted, and the copper lead wire is bent over the edge of the test tube so that only the electrode is in contact with the solution.

Certain metals require special treatment before use. The following directions are given:

Aluminum. Dip into a test tube of 6 *M* HCl until bubbles of hydrogen are observed all over the surface. Do not rinse. Use immediately, before the oxide coating reforms.

Magnesium, Zinc. If the metal appears oxide coated, dip quickly into dilute HCl then rinse with water.

Silver. Enough silver is produced by reduction on the surface of a graphite rod to function as a silver electrode. After cleaning the surface of a graphite rod with fine sandpaper, attach a 6-in. copper wire to the rod. The silver deposit is formed when the cell is assembled.

Indicator Strip. To indicate the direction of current, a strip of Universal *p*H indicator paper[7] moistened with saturated $NaNO_3$ may be placed across the lead wires as shown in Figure 1*b*. A blue color develops about the wire carrying electrons away from the galvanic cell, while a red color develops at the other wire. A strip of filter paper moistened with $NaNO_3$ containing a few drops of phenolphthalein provides a less sensitive indicator; also, a color change is observed at only one wire.

Comparison of Cells. Cells are compared by connecting their copper reference electrodes together and placing the indicator strip across the leads from the respective metal electrodes. (See Figure 2.) The number of comparisons made will depend on the metals available and the amount of time allotted to laboratory work. In a three hour period, students were able to construct cells and make comparisons with at least two others. Metals and comparisons were assigned in patterns of the type shown in Table 1. Such patterns are designed to provide for an appreciable difference in voltage between cells being compared, to insure that each individual would have different results to report, and to avoid congestion and confusion.

One or two voltmeters per class are sufficient to permit students to obtain numerical values for the voltages of their cells. These can be compared with $E°$ calculated from tables. Though agreement with the calculated $E°$ is seldom good, the experimental values are consistent and precise. The students may be encouraged to investigate the reasons for the discrepancy.

Reports. The student is required to make schematic diagrams of the cells which he has constructed, labeling the parts of the cell and indicating the directions of electron flow and ion migration. He must write electrode reactions and balanced cell reactions and then compute the $E°$'s for the cells. Finally, he is to arrange the metals which he compared into an abbreviated electromotive series. All of this is done in the laboratory as part of the experiment, and all work is handed in before the student leaves the class.

Results

Nearly all students were able to determine the direction of electron flow from their cells by observing color development on indicator paper. Measurements using inexpensive voltmeters[8] gave results which were always lower than the $E°$'s calculated from tables. However, students working independently on the same assigned cells obtained voltages that were similar and reproducible. Voltages from combination cells were also lower than theoretical but were consistently in the same order as the electromotive series. This is shown in Table 2. In the table the values under "Cu" are those obtained from single cells.

Rough indications of the experimental electromotive series were obtained also from comparisons of the

[6] To prepare the salt bridge solution, add 30 ml of water to 0.6 grams of powdered agar in a 150 ml beaker. Heat on a water bath until the mixture appears homogeneous. Then add 8 drops of saturated $NaNO_3$ to the hot solution and leave on the water bath at low heat until all of the students have constructed their copper half-cells. The above quantity is sufficient for 25–30 students.

[7] "Universal *p*H Indicator Paper," from Will Scientific, Inc., New York, New York, or "*p*Hydrion" Paper, from Micro-Essential Laboratory, Brooklyn, New York.

[8] Weston Instruments Model 201, 0–3 v dc, 1000 ohms/v.

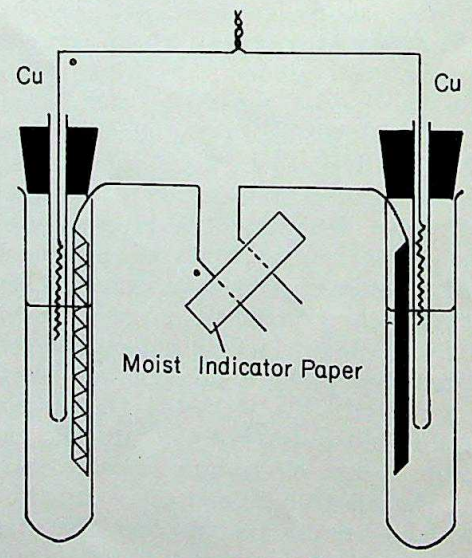

Figure 2. Arrangement for comparison of cells.

Table I. Assignment Pattern for Construction and Comparison of Galvanic Cells

Student no.	Metal electrode	To be compared with
1	Ag	Zn and Cd
2	Al	Mg and Sn
3	Cd	Pb and Ag
4	Fe	Mg and Sn
5	Mg	Al and Fe
6	Pb	Mg and Zn
7	Sn	Ag and Al
8	Zn	Pb and Ag

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relative times required for the development of perceptible color changes on the indicator paper.

Some precautions should be noted. Obtaining a color change in a reasonably short time requires that the maximum current be delivered by the cell. Aside from faulty connections of the lead wires, the chief factors which reduce the current are a poorly constructed salt bridge and inadequately cleaned electrodes.

Table 2. Typical Voltages from Combination Cells

	Al	Zn	Fe	Sn	Cu	Ag
Mg	0.32	0.45	0.43	0.50	1.05	1.35
	Al	...	...	0.17	0.58	0.80
		Zn	...	0.13	0.54	0.75
			Fe	0.12	0.52	0.72
				Sn	0.42	0.65
					Cu	0.32

(Al and Zn are particularly bad offenders.) For a good salt bridge, the constriction at the end of the 6 mm inner tube should have an opening of at least 2 mm. A *minimum* of cotton should be *loosely* inserted at the constriction. To avoid rapid oxide formation on the metals, the solutions of Al^{3+} and Zn^{2+} should be slightly acidified. If the electrodes are used promptly after being cleaned with acid, they will work properly.

The cells are compact, sturdy, and portable. Copper reference half-cells left standing in water were still usable after 10 days. Thus, if necessary, it is possible to extend the experiment over more than a single laboratory period. Although they have not been used in the general laboratory classes, half-cells containing mixed ions such as Fe^{2+}, Fe^{3+}, and a graphite electrode have been shown to be feasible in the cell design described herein.

For small classes or for selected students, many variations are possible. As was suggested by Gorman,[3] "unknowns" may be assigned to be located in their appropriate places in the electromotive series, and concentration cells or nonmetal-anion cells may be designed.

Student response to this experiment has been gratifying. They have derived considerable pleasure in constructing and comparing the cells, and their interest has been reflected in a better understanding of this part of the general chemistry course.

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An Approximate Wave Mechanical Treatment of the Harmonic Oscillator and Rigid Rotator

Undergraduate physical chemistry courses do not often have time for an exact derivation of the energy levels of the harmonic oscillator. For real molecules, moreover, the "exact" treatment is only approximately valid since they are not truly harmonic oscillators. This note presents a simple approach that introduces the significant features of the energy equation for the lower levels. It leads to values of the separation between adjacent energy levels which are too small by less than 23% although the zero-point energy comes out 57% too large. For the rigid rotator, a similar approach leads to the same result as that of Bohr, but with the advantage of a wave-mechanical basis.

The potential energy of a one-particle harmonic oscillator, according to elementary classical physics, is

$$V = kx^2/2 \qquad (1)$$

where k is the force constant and x is the displacement. This energy is the total energy at the extreme displacements, where x is $\pm a/2$, with a representing the range of the vibration. Since the total vibrational energy is constant, we have

$$E = ka^2/8 \quad \text{or} \quad a = (8E/k)^{1/2} \qquad (2)$$

We now approximate the oscillating particle as a free particle in a box with a length a equal to the classical range of its oscillation as given by equation (2). The wave-mechanical equation for the energy is

$$E = n^2h^2/8ma^2 \qquad (3)$$

Substituting the value of a from equation (2) we find

$$E = n^2h^2/8m(8E/k) \qquad (4)$$

or

$$E^2 = n^2h^2k/64m \quad \text{and} \quad E = (k/m)^{1/2}nh/8 \qquad (5)$$

where n, as in equation (3), is a positive integer. The well-known exact result is

$$E = (k/m)^{1/2}(n + {}^1/_2)h/2\pi \qquad (6)$$

where n can be zero as well as positive. Approximate wave functions can also be derived from equation (5).

The rigid rotator in two dimensions can be handled from a similar perspective. Here a in equation (3) must equal πr, half the circumference (length) of the curved "box" with radius r, so that interference does not occur. We then have as in Bohr's derivation.

$$E = n^2h^2/8m\pi^2r^2 = n^2h^2/8\pi^2I \qquad (7)$$

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The theory of the Formaldehyde Clock Reaction

The "formaldehyde clock" reaction has been recommended, both in THIS JOURNAL[2] and the *School Science Review*[3] as an experiment suitable for lecture demonstration and for students to perform. It is indeed a "tested" demonstration.[4]

A theory of the reaction, first given by Wagner[5] has been accepted by later authors. Our purpose is, first, to point out that Wagner's theory is quite unsound and, secondly, to give a more satisfactory explanation. According to Wagner, the following reactions occur:

$$HCHO + HSO_3^- \rightarrow CH_2(OH)SO_3^- \quad (1)$$

$$H_2O + HCHO + SO_3^{2-} \rightarrow CH_2(OH)SO_3^- + OH^- \quad (2)$$

$$OH^- + HSO_3^- \rightarrow SO_3^{2-} + H_2O \quad (3)$$

Reactions (1) and (2) are regarded as rate-determining, reaction (3) as instantaneous. Reaction (2) is introduced to account for the observation that the reaction time τ (the time taken from initiating the reaction to observing an indicator color change) is decreased by increasing the initial sulfite concentration at constant initial formaldehyde and bisulfite concentrations. It is considered that the pH increases only when all the original bisulfite is used up.

Our objections are as follows. (1) The theory supposes that a chemical reaction can go to *completion* in a *finite* time which can be altered by changing initial concentrations; this is clearly wrong. (2) The theory ignores the buffer action of the sulfite/bisulfite system:

$$HSO_3^- \overset{K_a}{\rightleftharpoons} SO_3^{2-} + H^+ \quad (4)$$

$K_a = 6.7 \times 10^{-8}$ at 25°C. We show below that, if this equilibrium is taken into account, the effect of changing sulfite concentration is accounted for without involving the improbable termolecular process equation (2).

We suggest that the kinetics of the formaldehyde clock reaction can be explained simply in terms of reaction (1) and the rapid equilibrium (4). Reaction (1) is considered to be irreversible. The reaction time (τ) then corresponds to the time taken for reaction (1) to produce a change in $[H^+]$ from an initial value,

$$[H^+]_0 = K_a \frac{[HSO_3^-]_0}{[SO_3^{2-}]_0} \quad (5)$$

to a value at time τ given by

$$[H^+]_\tau = K_{in}(CR) = K_{in}' \quad (6)$$

where K_{in} is the dissociation constant of the indicator and (CR) is the indicator color ratio at which the end point is detected by an observer using a particular indicator concentration.

For simplicity of treatment we will assume that $[H^+]_0$ is determined by the initial stoichiometric buffer ratio and that $[SO_3^{2-}]$ remains constant up to time τ, i.e.,

$$[H^+]_\tau = K_a[HSO_3^-]_\tau/[SO_3^{2-}]_0$$

A rigorous solution leads to the same result as that obtained below, for the conditions used by Wagner.

For initial concentrations of formaldehyde (F_0), bisulfite (B_0) and sulfite (S_0) such that $F_0 > B_0$ the integrated second order rate equation between the limits $t = 0$ and $t = \tau$ is:

$$\frac{1}{F_0 - B_0} \ln \frac{B_0 F_\tau}{F_0 B_\tau} = k_1\tau \quad (7)$$

Making the appropriate substitution yields:

$$\frac{1}{F_0 - B_0} \log_{10} \frac{B_0(F_0 - B_0 + (S_0K_{in}'/K_a))}{F_0\left(\frac{S_0K_{in}'}{K_a}\right)} = 0.43k_1\tau \quad (8)$$

Since for phenolphthalein $K_{in}'/K_a \sim 10^{-2}$, $(F_0 - B_0) \gg S_0(K_{in}'/K_a)$ in Wagner's experiment.

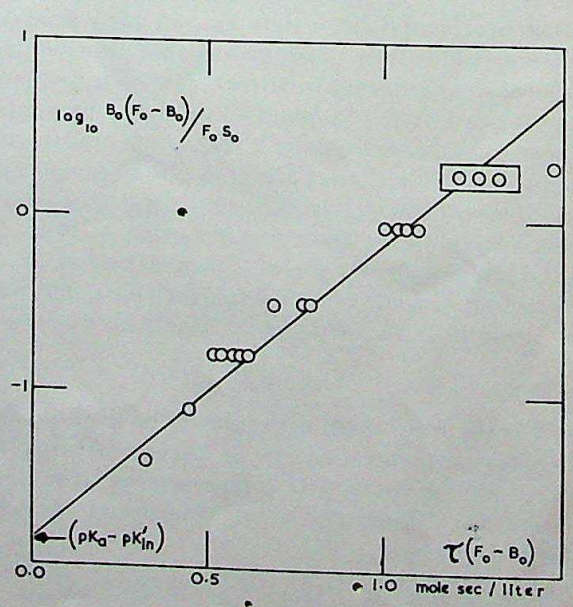
Introducing this simplification, (8) rearranges to

$$\log_{10} \frac{B_0(F_0 - B_0)}{F_0S_0} = 0.43\, k(F_0 - B_0)\tau - (pK_{in}' - pK_a) \quad (9)$$

In the graph Wagner's original data are compared with equation (9). This yields the values

$$k = 3.9 \text{ liter mole}^{-1}\text{sec}^{-1} \text{ and } (pK_{in}' - pK_a) = 1.9$$

There is some spread of the results and this is hardly surprising when the following sources of error are con-



[1] On August 1, 1963, King's College will become the University of Newcastle upon Tyne.
[2] BARRETT, R. L., J. CHEM. EDUC., 32, 78–9 (1955).
[3] CHISMAN, D. G., *Sch. Sci. Rev.*, 38, 100–1 (1956).
[4] ALYEA, H. N., AND DUTTON, F. B., eds., "Tested Demonstrations in Chemistry," 4th ed., Chemical Education Publishing Co., Easton, Pa., 1960, p. 59.
[5] WAGNER, C., *Ber.*, 62, 2873–7 (1927).

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sidered. (1) There are timing errors if, at the endpoint, dpH/dt is small. We have followed the reaction using indicator and a recording pH meter simultaneously and have shown that the phenolphthalein end point does not always occur in a region of rapidly changing pH. (3) In Wagner's work the ionic strength varied considerably between experiments (from about 0.1 to 1) so that K_a, K_{in}' and probably k_1 would not remain constant. (4) Autoxidation of sulfite to sulfate may cause an increase in the apparent τ, or the end point may not appear, or it may appear and rapidly disappear (competition from an "oxygen clock"). The three points enclosed by a rectangle in the graph indicate the reproducibility Wagner obtained under a single set of conditions.

(2) Barrett[2] found a linear relation between τ and dilution when the ratios $[F_0]:[B_0]:[S_0]$ were kept constant. We do not understand his explanation but this result is readily accounted for by equation (9). Barrett[2] also gives an empirical linear relationship between temperature (in °C) and log τ. We do not regard this as a useful student exercise since the empirical relation has no theoretical significance, and the function actually describing the temperature coefficient of τ is complex, involving the temperature coefficients of k_1, K_a and K_{in}'.

Acknowledgment. We wish to thank Dr. A. K. Covington for the use of the recording pH meter and Dr. M. L. Haggett for experimental assistance.

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Flowing Clock Reactions

Textbooks of undergraduate experimental physical chemistry contain no experiments on the study of fast reactions, although it is 40 years since Hartridge and Roughton dramatically extended the accessible range of reaction velocities by the introduction of flow methods.[2] It seems probable that this omission originates in the cost and complexity of the fluid drives and measuring devices used in the conventional application of flow techniques. Our purpose is to point out that quantitative kinetic studies may be made with great simplicity on the time scale 0.01–1 sec by applying the continuous flow principle to the study of clock reactions. The fluid drive is an ordinary water jet suction pump, the measuring device is a ruler. We describe below the apparatus and its application to the study of the "iodine clock" (hydrogen peroxide + iodide) and "formaldehyde clock" (formaldehyde + bisulfite) reactions.

Apparatus. A diagram of the apparatus is shown in Figure 1. The apparatus consists of two reactant solution reservoirs (250 ml measuring cylinders), each with a siphon tube connected to the T-tap (1 mm bore) mixing chamber (A). The flow tube (2 mm bore) of about 1 meter length is connected between the mixing chamber and an auxiliary tap (B), by means of which suction can be applied from a water pump.

Preliminaries. Fill both cylinders with water, fully open both taps A and B, and turn on the water pump. Experiment with different settings of the water tap (C) determining the flow rate at each setting. The maximum flow rate with an apparatus of these dimensions is about 10 ml sec^{-1} (5 ml sec^{-1} from each reservoir), but any flow rate down to 3 ml sec^{-1} may be used. Flow at rates of less than this minimum may cease to be turbulent,[2] as required for a sharp boundary. The flow rate is measured in the following way: open tap B starting a stop-clock at the instant of opening; when at least 50 ml has been removed from each cylinder, close B, noting the time of closure. Re-read the level in each cylinder immediately and compute the

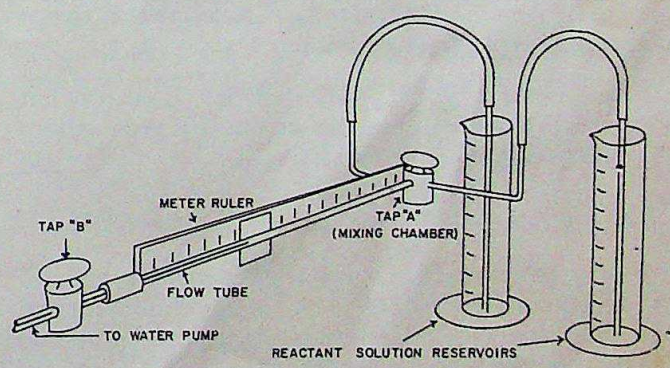

Figure. 1. Diagram of the apparatus.

separate and total flow rates. If the volumes leaving the two cylinders differ from each other by more than a few per cent, adjust tap A to remove this difference. After the correct setting of A has been achieved do not disturb it.

Method. For both the experiments detailed below each mixture should be prepared immediately before the run. It is convenient to make up the mixtures by measuring directly into the reservoir cylinders from stock solutions. Make sure the mixed solutions are well stirred.

[1] On August 1, 1963, King's College will become the University of Newcastle upon Tyne.

[2] Roughton, F. J. W., in "Technique of Organic Chemistry," Freiss, S. L., and Weissberger, A., eds., Vol. 8, Interscience Publishers, Inc., New York, 1953, pp. 669–90.

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Turn on C and open B. Adjust C until the endpoint (color boundary) is at a convenient position in the flow tube. Now carry out a flow rate (f) determination as before; but during the waiting period, measure the distance (x) between the mixing chamber and the color boundary. A white card held behind the flow tube is useful in detecting the boundary. Alter the flow rate and repeat the determinations of f and x. Calculate the reaction time (τ) for each set of measurements:

$$\tau = \frac{x \cdot A}{f} \quad (A \text{ is the cross sectional area of the flow tube})$$

Two Examples

Formaldehyde Clock Reaction. The theory of this reaction has recently been discussed.[3] The most convenient experiment to carry out is the dilution experiment due to Barrett.[4] In this experiment the ratios $[HCHO]:[HSO_3^-]:[SO_3^{2-}]$ are kept constant but their total concentrations are varied. Under these conditions the reaction time (τ) is related to the dilution ($1/C$) of any component by the equation:[3]

$$\frac{1}{C} = Ak\tau$$

where k is the reaction velocity constant for the addition of formaldehyde and bisulfite and A is a constant depending on the indicator used and its concentration.[3]

Suitable recipes are as follows:

buffer: 0.3 M SO_3^{2-} + 0.05 M HSO_3^-

	Reservoir I			Reservoir II	
Experiment	Buffer solution (ml)	Phenol phthalein (ml)	Distilled water (ml)	1 M Formaldehyde solution (ml)	Distilled water (ml)
1	120	2	128	120	130
2	60	2	188	60	190
3	30	2	218	30	220
4	15	2	233	15	235

A set of results obtained with this reaction is shown in Figure 2—note the time scale.

Iodine Clock Reaction. The reaction is carried out under conditions such that the reactant concentrations are maintained effectively constant, i.e.,

$$-\frac{d[H_2O_2]}{dt} = \frac{d[I_2]}{dt} = k[H_2O_2]^a\,[I^-]^b\,[H^+]^c = \text{constant.}$$

The extent of reaction which is measured is controlled by addition of thiosulfate to the reaction mixture and the detection method is starch indicator. The end point corresponds to the condition:

Molarity of iodine produced by reaction = ½ (Initial molarity of thiosulfate in reaction solution)

$[I^-]$ is kept constant by the very rapid reaction of the iodine produced and thiosulfate, $[H^+]$ and $[H_2O_2]$ by virtue of their large excess.

A suitable experiment is to determine the order with respect to each of the reactants, by changing their concentrations in turn (at the concentrations used the contribution of the acid-independent path is negligible), and hence obtain the (third-order) rate constant. Suitable recipes for 18–20°C are at the bottom of this page.

Conclusions

Students tend to divide reactions into "instantaneous," "measurable," and "slow"; measurable reaction rates are considered to be those in which concentration changes are slow enough to be followed by conventional analytical techniques, but fast enough that significant concentration changes occur within a laboratory session. Their time scale is thus limited to about 10^2–10^4 seconds. We have recently designed kinetic experiments which may remove these arbitrary distinctions by allowing students to carry out kinetic experiments where the time scale involved in the measurements varies from 10^{-2} to 10^6 seconds. The fast reactions are particularly important since these studies reflect the interest of much current research and provide students with the stimulus of working on time scales much smaller than are normally within their experience.

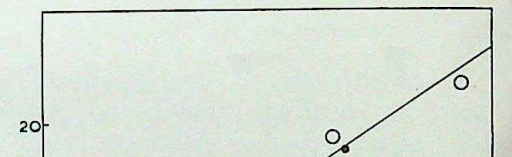

Figure 2. Plot of results from the formaldehyde clock reaction.

The flowing clock technique is not without flexibility. We have made preliminary studies of the sulfite + hydrogen peroxide and formaldehyde + ammonia reactions, and it seems likely that the method offers possibilities for original kinetic investigations.

The two reactions which we have described above can be studied by a conventional clock technique; we have speeded them up by concentration increases so that a flowing clock technique is applicable. However, it is probable that inherently faster reactions can be studied by this technique.

[3] Jones, P., and Oldham, K. B., J. Chem. Educ., 40, 366 (1963).

[4] Barrett, R. L., J. Chem. Educ., 32, 78–9 (1955).

	Reservoir I			Reservoir II			
Experiment	4 M H_2O_2 (ml)	2 M HCl (ml)	Distilled water (ml)	0.05 M KI (ml)	0.01 M $Na_2S_2O_3$ (ml)	Distilled water (ml)	Starch solution (ml)
1	125	125	0	100	100	0	50
2	62.5	125	62.5	100	100	0	50
3	125	62.5	62.5	100	100	0	50
4	125	125	0	50	100	50	50

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Placement in General Chemistry

With the increasing diversity of preparation—as well as the usual diversity of intellectual capacity—found among students entering the general chemistry course, placement has become essential. A three-year study has been conducted at Northern Illinois University to try to find a satisfactory method for placing students in Chemistry 210, a course primarily for chemistry majors and those whose future field of specialization requires rigorous preparation in chemistry. Chemistry 210–211 is a traditional year course including qualitative analysis in the second semester, Chemistry 211. The text used in 1960–1 was "General Chemistry, A Systematic Approach," second edition, by H. H. Sisler, C. A. Vanderwerf, and A. W. Davidson. Although the text was changed during the study, apparently this did not influence the results. The students used as subjects came from very diverse backgrounds: from large cities such as Chicago and from small farming communities. As the study progressed admission requirements to the University became more stringent. Enrollees in Chemistry 210 are required to have better preparation in mathematics than for the other beginning chemistry courses offered at Northern Illinois University.

On the hypothesis that students would benefit from being in classes where the abilities and preparation of other students are not too different from their own, the Office of Testing Services was requested to undertake a study of the marks earned by students in Chemistry 210 and the relationship of these marks to certain objective measures available for the students. For the purpose of the study it was assumed that ability in chemistry is measured by the mark in the course. The question was whether another criterion of this ability might be available prior to entrance in the course. A pilot study using entering freshmen taking Chemistry 210 in the fall of 1958 revealed that some of the objective measures related to ability in chemistry were the score on a mathematics test, the total score on the scholastic ability test, and the reading comprehension score. It was decided to compute biserial r's using the criteria of "success" and "failure" as the arbitrary dichotomy. Success was defined as A or B; failure as F or D.

Relationships between marks in Chemistry 210 and objective test scores were studied relative to the entering freshmen in the fall of 1959 (see the table). Results indicated that the mathematics test score would have been the best criterion for placing the students studied. It seemed doubtful that any chemistry test *per se* could yield as high a correlation. Thus, the mathematics score was used the following year as an experimental criterion to divide Chemistry 210 courses roughly in half for sectioning purposes. It was decided that the grade in the course would be based primarily on the material common to the different sections. The higher level sections were enriched rather than accelerated.

One of the authors constructed a trial test to see whether a specific examination related to the skills commonly believed to be essential to success in beginning chemistry might prove better for placement of the students. The "Chemistry Placement Test"[1] consists of three parts: straightforward arithmetic problems and chemical problems stated as analogous everyday word problems; an intellectual ability part in which the student is called upon to read unfamiliar scientific material and answer questions about it; and a factual part based on recall of high school chemistry. The examination is entirely objective.

The experimental chemistry placement test was given to all students in Chemistry 210 in the fall semester of 1960–61. The Office of Testing Services again correlated chemistry marks with objective test scores available and with data from the chemistry placement test. The very high biserial correlation of the experimental chemistry test scores (r_{bis} = 0.926) with the final grades in Chemistry 210 as compared to the correlation with the mathematics scores, r_{bis} = 0.755 for the ACT Mathematics Standard Score, was sufficient encouragement to continue the study.

[1] SCHELAR, V. M., "Chemistry Placement Test," copyright 1963.

Biserial Correlations of Test Scores with Final Grades in First Semester Chemistry 210

Tests	Correlations 1959–60	1960–61	1961–62
Coop. Math[a]	0.9314	0.731	0.625
SCAT Q[b]	0.81	0.559	0.526
SCAT T[b]	0.6859	0.83	0.655
ACT Math[c]	...	0.755	0.629
ACT M′[d]	...	...	0.657
CPT[e]	...	0.926	0.860
	N = 83	N = 115	N = 124

[a] "Cooperative Mathematics Pretest for College Students," Form X, Cooperative Test Division, Educational Testing Service, Princeton, N. J., 1947.
[b] SCAT ("School and College Ability Tests"), Form Cl, Cooperative Test Division, Educational Testing Service, Princeton, N. J., 1957.
[c] ACT ("American College Test"), Iowa City, Iowa, 1960.
[d] ACT M′: The predicted grade point average (GPA) in mathematics based on ACT Standard Test Scores and GPA's at Northern.
[e] CPT ("Chemistry Placement Test"), Virginia M. Schelar, 1963.

Based on a paper read before the Division of Chemical Education at the 144th Meeting of the American Chemical Society, Los Angeles, April, 1963.

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In the fall of 1961 students were again placed in separate classes according to mathematics test score. One-third of the students were in upper sections and two-thirds in the lower. As a result of an item analysis the "Chemistry Placement Test" now had 43 five-item multiple choice questions chosen from the 66 in the experimental test.

The table summarizes the findings in the three years the Chemistry 210 classes were studied. The type of sectioning done probably accounts for the instability of the SCAT predictive ability. Although the Cooperative Mathematics Test was the best predictor in 1959–60, in 1960–1 it was next to the lowest. (In 1959–60 no "Chemistry Placement Test" was given.) The ACT M′ which was computed from the American College Test Prediction Equation for Mathematics is not a significantly better predictor of success in chemistry than the test results of any of the other tests evaluated. A related study (data not shown) caused the rejection of the hypothesis that there is a significant positive relationship between completion of high school chemistry and success in Chemistry 210 at Northern Illinois University. There is little doubt that the "Chemistry Placement Test" is a better instrument to use in placement at Northern than any of the other data available. Both in 1961–2 and in 1960–1, its predictive ability was significantly higher than any of the other data available at Northern.

It is hoped that despite the local nature of the study, the results may be of value to others in planning placement examinations. Northern Illinois University is a state supported school with an enrollment of approximately 8000. Further details may be obtained from the author. Grateful acknowledgment is made of the cooperation of five members of the Department of Chemistry who were at various times engaged in teaching Chemistry 210 during the course of this study.

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An Evaluation of the Toledo Chemistry Placement Examination

Eight years ago the authors, being disturbed by the high percentage of failures in the general chemistry course at the University of Toledo, began a study of this problem. This study[1] showed that the best single criterion for prediction of failure in general chemistry was a combination of the scores on the Iowa Chemistry Aptitude Test and an achievement test based on knowledge of high school chemistry. At that time we suggested that these two tests might be replaced by a new examination containing items of the type found to be statistically most valid on the other two tests. The advantage in this was to administer a single examination in one hour, rather than to give both tests which required two hours. The demand for reprints of the published paper and the number of letters of inquiry concerning the availability of such an examination lead to the decision to develop, publish, and arrange for distribution of the Toledo Chemistry Placement Examination (TCPE).

The test was made available in the fall of 1959. Sales have totaled 9000 tests and 24,000 answer sheets in addition to 230 specimen sets. The extensive use of the present examination imposes a clear obligation on its authors to make an alternate form available for reasons of security.

Before publishing a new form of the examination, it seemed appropriate to undertake a thorough evaluation of the original examination and the consequences of its use in sectioning beginning chemistry students at the University of Toledo.

The examination is of the multiple-choice single response type. The time allowed is 55 minutes. The organization into parts and the method of scoring are indicated in Table 1. The IBM answer sheets were designed so that they could be scored by hand or by machine.

Table 1. Organization and Scoring of the Toledo Chemistry Placement Examination

Part	Items	Scoring	Points
I. Arithmetic and algebra	15	Rights × 1	15
II. General knowledge	25	Rights × 1	25
III. Formulas and nomenclature	10	Rights × 1	10
IV. Equations	6	Rights × 2	12
V. Algebraic formulations	6	Rights × 3	18
VI. Chemical problems	5	Rights × 4	20
Total	67	...	100

Readers desiring additional information on the TCPE are advised to write the Research Foundation, University of Toledo, Toledo 6, Ohio. Specimen sets are available at 50¢ each. Tests are priced at $5.00 per package of 25 and answer sheets are 4¢ each. The new form will be available for late summer and early fall testing.

Presented before the Division of Chemical Education at the 144th Meeting of the American Chemical Society, Los Angeles, April 1963.

[1] Hovey, N. W., and Krohn, A., J. Chem. Educ., 35, 507 (1958).

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The Statistical Analysis

All answer sheets for Toledo students for the academic years 1959–0, 1960–1, and 1961–2 were arranged in order of decreasing score. These tests had been administered to prospective freshmen with at least one year of high school chemistry who planned to take the regular general chemistry course. By removing a small number above and below the median, the number of answer sheets was reduced to 1000. These were then used to establish norms (percentiles), the standard deviation, and the reliability coefficient (Table 2).

Table 2. Norms for the Toledo Chemistry Placement Examination

Percentile rank	Score	Percentile rank	Score
99	93	45	53
95	85	40	51
90	78	35	49
85	75	30	47
80	70	25	45
75	68	20	42
70	66	15	38
65	63	10	34
60	60	5	29
55	58	1	19
50	55		
Standard deviation = 16.8		Reliability coefficient = 0.921	

The reliability coefficient was estimated by means of the Kuder-Richardson formula number 21.[2] (This is the reliability of the test itself. Correlation of these scores with actual performance in the course is given later.)

The highest 27% and the lowest 27% were used to obtain the percentage in each group which chose each of the four possible responses to each of the 67 items. Using these data, the values for the item-difficulty index and the item-discrimination index were obtained by use of the Item Analysis Table published by the Educational Testing Service.[3] A summary of the item analysis is available to users of the test on request.

The reliability coefficient of 0.921 is entirely satisfactory. The spread of responses in the low group indicated that the incorrect answers (distractors) were effective. The item-discrimination indexes are very high. Of the 67 items, 20 are outstanding (discrimination index r = 50–69), 25 are very good (r = 40–49); 18 are acceptable (r = 30–39) and only 4 could be rated unacceptable (r less than 30). It is somewhat shocking to observe that the least discriminating question involved recognition of HNO_3 as an oxidizing agent. In the high group 31% and in the low group 34% chose "reducing agent" as the correct response!

The TCPE has proved to be very satisfactory at the University of Toledo for the purpose of determining which students should be denied direct admission to general chemistry. The cut-off score of 40 was low enough to insure that very few students capable of earning a C grade in the first semester of general chemistry (Chem 117) are denied direct admission to this course. The number of F grades in Chem 117 has decreased from over 30% in 1954 to approximately 10% per year for the past three years.

The deficiency course for those scoring below 40 on the placement test has been drastically revised since our 1958 report. The present course (Chem 109) consists of three hours of lecture and quiz and one three-hour laboratory period per week for one semester. Students entering without credit in high school chemistry are also required to take this course. Students in both groups must earn a minimum grade of C in Chem 109 before being admitted to Chem 117.

Predicting Achievement

We also have data on the reliability of the TCPE as a predictor of achievement. We realize that motivation plays such an important role in determining course grades of those above the cut-off point that a high correlation between the TCPE scores and grades in Chem 117 is unlikely. Educational psychologists state that the maximum correlation between placement test scores and college grades is probably 0.7, even with a perfect test battery.[4] Prediction of a single course grade by means of a single test is even more difficult.

To obtain some measure of the motivation factor as related to the students' professional goal, we divided the 900 students whose records were used for this study into five groups based on the program in which they were enrolled. We also sought to determine whether there is any significant difference in the chemistry grades of students from different geographical areas.

Since our present placement program in general chemistry went into effect in 1958, we have kept a complete record of every student enrolling in Chem 109 (the deficiency course) and in Chem 117 and Chem 118 (the college-level general chemistry courses). From these records for the academic years 1959–60, 1960–1, and 1961–2, the records of 900 students were selected for this study. (After eliminating the records of foreign students and all who had taken Chem 109 before enrolling in Chem 117, about 930 records remained. By removing records of students who dropped out for reasons other than to avoid failure, and by withdrawing a few records from the middle range, the number was adjusted to exactly 900.) The grade distribution for these students was next obtained. The 900 placement scores were then assigned letter grades to give approximately the same distribution as for the grades actually earned in Chem 117 for the three-year period.

The letter grades earned by the 900 students in Chem 117 are compared with their grades on the TCPE in Table 3. We see that 45.1% of these students earned the grade predicted by the test. The correlation coefficient based on this table was estimated to be 0.54. We can predict that 83% of those who score above 84 on the placement test will rate A or B in Chem 117 and 68% of those who score below 46 will rate D or F. Our conclusion is that, in combination with other criteria, the TCPE should be of value in selecting students for an Honors course in General Chemistry. It also shows that prediction is less accurate in the middle score ranges where motivation and other outside factors have a greater impact on the student's performance.

[2] Kuder, G. F., and Richardson, M. W., *Psychometrika*, 2, 251 (1937).

[3] Fan, C., "Item Analysis Table," Educational Testing Service, Princeton, N. J., 1952.

[4] Travers, R. M. W., "Educational Measurement," Macmillan Co., New York, 1955, p. 65.

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It should be kept in mind that the TCPE was not designed to predict achievement, but rather to separate those who were capable of passing Chem 117 from those who were not. This it has done, since nearly 95% of those who scored above 45 on the placement test passed the course (90% of those above 40). Our previous study indicated that only about 10% of those below the cut-off score of 40 would have passed the course had they been admitted.

It is interesting to compare our experience with the test with that of 11 Junior Colleges in California who have been using the test for the past two years.[5] Their data were in different form, so the Toledo grades were re-tabulated for comparison as shown in Table 4. About 65% of the California students who scored below 40 in the TCPE failed to pass the course. No direct comparison can be made with the Toledo students in this range since they were excluded from the regular course. It is not surprising that the correlation in the case of the California schools is not quite as good as for Toledo. Grading practices would be expected to vary more in 11 different schools than in a single department.

Our somewhat limited study of the motivation factor indicates that neither professional goal nor high school location are very significant in relation to achievement as predicted by the placement score. We found that chemistry majors and chemical engineering students, although they had higher test scores than the other groups, did not actually earn as high grades as might be expected. The pre-pharmacy group, on the other hand, had the lowest average on the TCPE but earned grades higher than those predicted. The pre-medical group also tended to perform higher than their placement scores predicted. We suspect that motivation is so complex and so personal that any statistical approach one might devise will yield very little useful information.

[5] Hein, M., and Reifsnyder, H., "Grades in Chemistry 1A Related to Toledo Chemistry Placement Examination Scores," private communication, Mt. San Antonio College, 1962.

Summary and Conclusions

Although a single one-hour placement examination such as the Toledo Chemistry Placement Examination predicts with satisfactory accuracy which students should be denied direct admission to a college level general chemistry course, it is of much less value as a predictor of achievement in the higher score ranges. The examination could be used as one criterion in selecting students for honors programs in general chemistry. It is unlikely that any student scoring less than 70 on the TCPE should be considered for such a program, since only about 15% of those below this score made A or B grades in the regular general chemistry course. On the other hand, it would be unwise to automatically accept all students with high placement scores in light of the fact that only 49% of those in the A placement range (84–100) actually earned an A grade in the general chemistry course.

Based on the statistical analysis, it is our conclusion that the TCPE is statistically sound and that no drastic revision is needed in the preparation of an alternate form.

Table 3. Letter Grades Earned in Chem 117 versus Grades Predicted by TCPE Score.

TCPE score	Letter grade TCPE	Number in range	Chem 117 Grades A	B	C	D	F	Number predicted correctly	Per cent predicted correctly
84–100	A	75	37	25	10	2	1	37	49.3%
71–83	B	164	22	58	64	16	4	58	35.4%
53–70	C	395	14	68	223	66	24	223	56.4%
46–52	D	173	1	10	78	55	29	55	31.8%
40–45	F	93	0	0	30	30	33	33	35.5%
Totals		900	74	161	405	169	91	406	45.1%
Per Cent			8.2	17.9	45.1	18.8	10.0		

Table 4. A Comparison of California and Toledo Grades versus TCPE Scores.

TCPE score	Cases Cal.	Cases Tol.	% A, B, C Cal.	% A, B, C Tol.	% D Cal.	% D Tol.	% F Cal.	% F Tol.
90–100	18	36	94.4	94.4	0.0	2.8	5.6	2.8
80–89	87	80	85.0	96.2	3.5	3.8	11.5	0.0
70–79	260	146	76.1	86.3	7.7	10.3	16.2	3.4
60–69	429	203	65.1	80.8	12.1	15.3	22.8	3.9
50–59	638	243	49.0	66.7	20.1	22.6	30.9	10.7
40–49	481	192	36.8	40.0	21.8	33.4	41.4	26.6
30–39	253		20.0		18.2		61.7	
20–29	92		9.8		17.4		72.8	
10–19	16		0.0		37.5		62.5	
0–9	1		0.0		0.0		100.0	
Totals	2275	900	49.2	71.2	16.5	18.8	34.3	10.0

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The Professional Presentation of Scientific Papers

A well-prepared subject, elegantly expressed by a speaker who is convinced that he has something to say, can be a joy to listen to. It can be a joy to him who gives it, for he can see the light of intelligent comprehension in the faces of his audience, and he can sense that his presentation has the marks of craftsmanship upon it. Every one gains from such an exchange.

How does he do it? Can you, whether an undergraduate, a graduate student, or an instructor, learn how to get the most out of your own talents, and perhaps experience this pleasure yourself? From my own experience with students I can say that the answer is "Yes." Given the will to take pains, to prepare, and to believe in himself, any intelligent person can become a good speaker. With imagination and ideas, he can become excellent.

In order to help those who would wish to examine and perhaps improve their presentation of scientific papers, I have drawn up a check-list of points to be considered. It has come from observing the reactions of audiences to lecturers, from listening to a considerable number of bad lectures and a small number of magnificent ones, and from reading books and articles on the subject. This check-list is offered here.

I assume throughout that you are not trying to incite the audience, or make a special appeal, or give a hortatory talk, or even to entertain, but to convey information. Your effort, then, is at communication. Here three factors can be considered, for the sake of clarity, though all are interrelated: the talk itself, the part played by you, and matters affecting the audience more personally.

The Speech

Prepare Beforehand. My wife knew a preacher who boasted that he never prepared his sermons: all he had to do was stand in the pulpit, and the Lord put the words into his mouth. But it was remarked frequently by the congregation that the Lord must have been occupied elsewhere. So, even though you have been living with the work, have just turned off the last stopcock, and made the last calculation, for the work you are about to report, *write it out.* It is instructive how many questions of organization suddenly turn up, how many decisions about what to include, and how many questions that require going to the literature. One or two of these, suddenly rearing their ugly heads while you are on your feet, can demoralize a talk even though the speaker may survive. I do not feel put-upon if a 45 to 50-minute talk needs 30 to 50 hours of preparation for writing, revising, documenting, and rewriting. A recent Sigma Xi lecture[1] was revised some eight times before and during its presentation on a tour, and the book on which it had been based was completely rewritten seven times over about ten years.[2]

Don't Try to Cover too Much. Very few lectures can have the compactness that is permitted in a written communication. The English language is about 50% redundant,[3] a feature which helps to combat "noise" and aids in getting the message through. Even so, you need to repeat and use several images, perhaps, to get your point across over the "noises" of all kinds that beset you. These may be external to the auditorium or lecture room—whose location often seems close to a truck route; or internal—you can include faulty public address systems, audience inattention, and so on.

Use Illustrations Wherever Possible. But again, don't try to cover too much. Make this simple calculation, and then shudder as the speaker brings in 60 slides for a 50-minute talk. If a scientific slide is well prepared and presented it can be used for a full minute or two. A slide per minute for fifty minutes becomes a travelog, but rarely a scientific talk. To show *all* the data is a great temptation to the novice who is perhaps justly proud of his tenacity and perspicuity in gathering it; but he should severely resist the temptation. The best cure is for him to attend one of the general sessions at a national scientific meeting. One or two horrible examples can save more souls than much exhortation.

Be Sure Slides Are Clean. I well remember attending a lecture on the Islands of the Aegean. The effect was totally destroyed by a large thumbprint in the center of every sky. Be harsh with the projectionist if necessary—but usually he will be careful about holding the slides, and *you* will have to get them clean. The old rule is "Right thumb in the upper right-hand corner only, then the slides will be properly set." Remember, too, that unsupported film can melt. If the slides are films, put them between glass plates.

Preferably, Don't Read the Paper. If necessary, memorize it. Or type it down one side of the page, leaving a two-inch margin on the left (or right). In this put a *few* key prompting words, written large. I also introduce a red asterisk for each slide—and any

[1] Cassidy, H. G., "The Problem of the Sciences and the Humanities, a Diagnosis and a Prescription," in "Science in Progress," 12th series, Brode, W. R., ed., Yale University Press, New Haven, Conn., 1962, pp. 93–116.

[2] Cassidy, H. G., "The Sciences and the Arts, A New Alliance," Harper & Brothers, New York, 1962.

[3] Shannon, C. E., and Weaver, W., "The Mathematical Theory of Communication," University of Illinois Press, Urbana, 1959, p. 104.

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necessary data about the slide in case difficult questions are asked. In any event, be sure the slides are in order. The speaker surprised by his own slide-arrangement does not convey confidence in the rest of his talk.

Sometimes I read passages when I want to be very precise; but I keep remembering a story told by Yale Professor Samuel Hemingway of the famous visiting lecturer who sat before a packed house in Strathcona Auditorium and read from the galley proofs of his forthcoming book—pausing to make corrections and cross out errors! He was never invited back.

Start Simply; if Possible Speak Simply. Tell what you are going to do, without giving away the climax. Use a range of emphasis and inflection; keep the sentences short unless you have an infallible sense for dependent clauses. This is a rare gift. Avoid dangling constructions and sentences that go nowhere. Technical jargon that might be necessary in a written work should be avoided if possible in a spoken. Especially eschew long variants of recognized words: irregardless, confliction, analyzation, commercialistic, optimization (and suboptimization) and (shudder!) tangibilitate. What may happen with jargon is that a lecture sounds as though it *might* make sense. We have all had this experience, and I recall an item that appeared in the Arthur D. Little bulletin some years ago[4] called "The Turbo-Encabulator." I quote only the first and last paragraphs to give some flavor of it.

> For a number of years now work has been proceeding in order to bring perfection to the crudely conceived idea of a machine that would not only supply inverse reactive current for use in unilateral phase detractors, but would also be capable of automatically synchronizing cardinal grammeters. Such a machine is the 'Turbo-Encabulator.' Basically, the only new principle involved is that instead of power being generated by the relaxive motion of conductors and fluxes, it is produced by the modial interaction of magnetoreluctance and capacitive directance. . . .
>
> Undoubtedly, the turbo-encabulator has now reached a very high level of technical development. It has been successfully used for operating nofer trunnions. In addition wherever a barescent skar motion is required, it may be employed in conjunction with a deep-drawn reciprocating dingle arm to reduce sinusoidal depleneration.

If these passages are read to an audience in a firm and well-modulated voice, with emphasis on the more unlikely words, many people are impressed even though vaguely disturbed.

Repeat Major Points and Introduce One or Two Interim Summaries. This can help the audience, and at the same time it can be used to develop a climax.

Try to Work towards Some Climax. This should preferably be one in which the preceding data all fall into place, or in which much falls into place, but some open questions are left. It is the height of artistry to let the audience—or some members of it—get the point themselves just before you state it.

Give Full Credit. The audience knows you didn't do all that work. If you actually did, you may even have to drop a gentle hint that you really did.

Posture Is Important. Try to be poised, calm, confident (but not overconfident). If you are nervous, there are tricks you can use to steady yourself. You can *slowly* adjust the cuff of your right sleeve with you left hand; you can remove your glasses slowly, to make a point. Watch how others do it. But don't lean on the desk or blackboard; don't fidget, or wriggle. I well remember my first public talk; it was to the entire population of Central High School, in Akron, Ohio. I had to present an award to one of the seniors for winning an essay contest put on by an honor fraternity in the university. I was so scared I could not keep my knees steady, and soon the entire front row of seniors were knocking their knees in unison! It was a traumatic experience for me.

Keep your hands out of your pockets, especially if they have chalk dust on them: few speakers can bring off the image of the untidy thinker unaware of the chalk dust smudges all over his dark suit.

Use the Blackboard Intelligently. Write on it clearly—print if you can—and large enough to be seen at the back of the room (test it if you are not sure). Let your formulas and structural diagrams be crisp and well drawn, not hurried and sloppy. Write with elegance. Don't stand in front of what you have written unless there is some reason for it to be kept from the audience, and *please,* don't erase immediately, or suddenly change signs throughout. Give your compulsive and other note-takers a break. Also, *please* erase completely and smoothly. Shards of previous writing left on the board by the erratic or swirler types of erasure-pattern makers can become confusing subscripts or exponents or even peculiar functional groups on later writing.

Remember That the Pointer Can Be a Weapon. There are two types of these weapons: rods and optical beam pointers. Rods should be used almost touching the screen so that the point of the shadow and that of the rod coincide. Few things are more annoying than to use the *shadow* of the pointer as an indicator, without letting the audience in on this off-beat trick. Don't touch the beaded screen with the pointer. A well-practiced screen-scraper can gouge a rain of beads from the screen with wild gyrations, and make the owner of the screen quite nervous. Use the pointer to point, not waggle; and when through with it, lay it down.

The light-spot or arrow pointer is a more dangerous weapon. Examine it beforehand, and learn how to focus it and to turn it off. Hardly anything is more fascinatedly demoralizing than the jiggling, winking, blinding spot, waved at the audience; or the woven arabesques on the ceiling and walls of the room made by the careless lecturer who has failed to turn the light off and put it down; or the fuzzy spot of the unfocused beam pointing doubtfully at some region of a slide. If your hand is not steady, use both hands, or steady them with elbow on the lectern or desk-top.

Avoid Monotonous Gestures. Sawing with the arm, stiff motions, stalking prey behind the lectern, and so on, are to be avoided.

Talk Slowly Enough to Be Understood, with a Well-modulated and Controlled Voice. Pause occasionally where emphasis is needed and, when a beginner, get some honest friend to listen to you and tell you about

[4] The full text of this significant contribution to scientific thought may be obtained from the public relations department of Arthur D. Little, Inc., Acorn Park, Cambridge 40, Mass. It is entitled "The Turbo-Encabulator in Industry," and its author is Mr. J. H. Quick, of the Institution of Electrical Engineers, London, England. It was published in that institution's *Students' Quarterly Journal,* December, 1944.

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speech idiosyncrasies. I once timed a very nervous graduate student in an average of twenty "uh's," "er's," and "ah's" per minute over a five-minute period; this is very hard on the audience.

Be very Careful of Expressions that Can Be Misinterpreted or Twisted by the Sophomoric Minds Present in Every Audience. Most of these that we have experienced cannot be printed, but a misplaced titter can be devastating. Remember that there are many ways of saying things. One man says "When I saw you, Time stood still." Another might say, "Your face would stop a clock."

It Is very Helpful to Have Demonstration Material Wherever Possible (Big Enough to Be Seen). This is made most effective if it is hidden from view—behind the desk, or in a paper bag—until just the right moment when it can be brought out to contribute to one of the high points or to a climax in the talk.

Plan Ahead. If much material is to be put on the blackboard, make up a drawing of the board with items arranged on it. If possible try it out ahead of time, and plan so that you can leave material as long as possible on the board as you work across it. This can be used for reference, and is very greatly appreciated by the audience. As you proceed by planned stages, writing everything out, or drawing diagrams, the whole talk takes on structure and increased intelligibility. Blackboard technique is an art.

Some years ago, Professor Joel H. Hildebrand prepared "A Speaker's Guide" which he has permitted me to quote.[5] It forms a summary for this section of the check-list.

"The first principle of effective public address is to attract and hold the attention of one's audience. Some rely mainly upon interesting material, well organized, clearly spoken, and illustrated, where appropriate, by slides and legible figures on the blackboard. It is not easy to fulfill all of these conditions, however, and the following devices may be used as substitutes.

Lean against the desk or the rail of the blackboard. This gives the impression of ideas in the brain so weighty as to be unsupportable on only two legs. If this does not suffice, one may butt the desk repeatedly with the rump. This is so fascinating as to make the audience less critical of what one says.

Juggle a piece of chalk. Juggling two pieces attracts even more attention. Balance a long crayon on end.

When writing on the board, hold the crayon at just the right angle to set up vibrations in it when it is pushed forward. The wail emitted is so pathetic that it cannot fail to arouse sympathy for the plight of the speaker.

Turn your back to the audience and talk to the board. This makes the audience try harder to get what you are saying. The same result can be achieved by lowering the voice, especially at the end of every sentence. Use "uh" to keep the audience "tuned in" while your brain catches up with your mouth. If you fear violations of "security" have your slides made at the Rad Lab, so that no one can read what is on them. Security with respect to items you write on the board is easily maintained by writing lightly. You can tell whether you write lightly enough by viewing your writing from different points in the auditorium.

While speaking, turn and look at what the preceding speaker left on the board. This directs attention to that material, and is a generous gesture to a colleague.

Pacing back and forth gives the impression of activity, of body, at least. The impression is heightened by a stern gaze directed upon the floor. For illustrations of the above practices look not at yourself but at your colleagues.

[5] I am indebted to Professor Joel H. Hildebrand for permission to reprint in entirety these important rules of conduct.

Avoid Apologies. "I really don't know too much about this"; I really haven't prepared"; "I just tossed together a few notes at the last minute." The audience may believe you and some may leave (mentally). In any case if true it will become all too apparent and doesn't need explicit statement; and it doesn't put you or the audience at ease.

No Snide Remarks. Along with avoiding apologies which belittle yourself, avoid belittling others. It is *not* funny to make puns on names. If you prove someone's work to be in error, be charitable. Perhaps he did not know as much as you now know. Science is cumulative. The speaker who wonders out loud in public how some scientist of fifty years ago missed some observation (while *he*, of course, saw it, with brilliant results) nauseates the more perceptive members of the audience and may convict himself as a fool if, as is often the case, there did not exist means for such observation at that time. Remember that high-vacuum and molecular distillation, UV, IR, NMR, glass electrodes, vacuum tube voltmeters and recorders, chromatography of all kinds, and most of the accessory instrumentation were just not available—or even not invented—fifty years ago or, some of them, ten or fifteen years ago. In any case, intellectual arrogance is one of the real sins that a speaker, or scholar, can commit. Be *ye* not guilty of it.

Never Show Disappointment. What if the equipment is poor, or nonexistent? Make do, with calm acceptance. After all, the chairman and the program committee may be embarrassed, too. *Never* worry about the size of the audience. Remember that the audience don't have to come, and they don't have to listen.

Don't Make the Audience Feel Insecure. Excessive erudition of the gratuitous kind is to be avoided. But the audience loves it if you lead them into a nice point that they see before you state it.

Don't Make the Audience Angry. There are many ways to be insulting. Dress to show that the occasion is important. One of the worst results of the beatnick approach is that the speaker implies to the audience that he lacks self-respect. Perceptive members of the audience react accordingly. You can be informal without being sloppy.

Local custom should be attended to. I recall one Summer Science Seminar in Bozeman, Montana, when it was very hot. I had to give a series of lectures. The first day I turned up with seersucker suit and tie. No-one had on a jacket. The next day I appeared without jacket. No-one had on a tie. The next day I was handed a gift-wrapped package, courtesy of the Director of the Program, with the request that I open and act accordingly. I left the room and returned, as instructed, wearing the loudest Truman-type yellow, green, and black sport shirt imaginable. I read out the gift card to the group: "To introduce you to the Montana Ivy League Look."

Start on Time. A common insult to the audience is the late start; start on time. This may require that you annoy the program chairman somewhat.

Sum up Briefly. But tell the audience what you have told them—in the large.

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I hope that this check list will be helpful to undergraduates, graduate students, and all those who wish to or have to speak about scientific subjects. I am sure that it is not exhaustive—human beings are full of ingenuity. But at least it can be used as a basis upon which you can construct your own list. So I conclude, in summary, with an anonymous quotation that appeared in a newspaper at least twenty years ago. I cannot give the author credit because I don't know who he is.

To combat your esoteric cogitations or in articulating superficial sentimentalities, philosophical profundities or psychological prognoses, beware of platitudinous ponderosity. Eschew jejune babblement and asinine affectation. Let even your extemporaneous discantations and unpremeditated expatiations have vivacity and intelligibility without rodomontade or thrasonical bombast. Sedulously suppress any polysyllabic propensities, paraphrastic euphuism, psittocaceous vacuities, ventriloquial verbosity and multiloquial bravardage. Shun double-entendre, prurient jocosity, and pestiferous, ingustible, or turgid profanity, whether obscure or apparent. In short, speak clearly, plainly, simply.

Richard E. Bozak[1]
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Chemistry at Moscow State University

The chemistry faculty[2] of Moscow State University is housed in a modern, six-story building directly behind the well-known main university building on Lenin Hills. It is the largest and most important university chemistry faculty in the Soviet Union, producing approximately one-half of the chemical publications originating in Soviet universities.[3]

We can learn about the function and aims of the faculty from the Faculty Bulletin or catalogue:[4]

The chemistry faculty prepares specialized chemists in five fields—inorganic, analytical, organic, and physical chemistry and radiochemistry.

Teaching and research in the chemistry faculty are directed by the decisions of the May, 1958, meeting of the Plenum of the Central Committee of the Communist Party of the Soviet Union. [This meeting dealt with] the acceleration of the development of the chemical industry and with the target figures for the national economy set by the Twenty-first Congress of the Communist Party of the Soviet Union.

Taken as working principles are the decisions of the Twenty-first Congress of the Communist Party of the Soviety Union which noted, "In the field of the chemical sciences, the paramount tasks are the general expansion of theoretical research, talented cultivation of new improvements in technological processes, and the creation of new synthetic materials with properties to meet the demands of contemporary industry."

In connection with these directives, the chemistry faculty has the task of significantly augmenting the preparation of chemical personnel, above all in the field of high molecular weight compounds.

The general study-plan of the faculty is intended to produce practical chemists with a broad background in physics and mathematics.

At the present time [1960], the chemistry faculty has in its complement fourteen departments (*kafedras*): physical chemistry, colloid chemistry, high molecular weight compounds, electrochemistry, chemical kinetics, the physics and chemistry of high pressure, organic chemistry, organic catalysis, the chemistry of petroleum, inorganic chemistry, general chemistry, radiochemistry, analytical chemistry, and chemical technology.

In the field of inorganic and general chemistry, scientific and academic work is conducted in the following specialties: the chemistry of rare elements, the chemistry of complexes and their application to industry, the chemistry of metals and alloys, the study of the equilibria of salts, and the study of refining processes for the production of new inorganic materials.

In organic chemistry, the faculty is producing specialists in the following fields: organic synthesis, investigation of the structure of organic natural and synthetic products and their application in different fields, the chemistry of metallo-organic compounds, the chemistry of proteins, the theory of organic catalysis and its use in industry, and organic microanalysis.

Research on the composition and structure of hydrocarbons derived from petroleum, synthesis in the oil industry, and the use of catalysis in the petroleum industry—all three problems are settled by the department of the chemistry of petroleum.

The department of physical chemistry, which has a great number of laboratories, prepares specialists for almost all areas in the chemical industry of the USSR. It is concerned with the study of the velocity of chemical reactions, inorganic catalysis, spectroscopy, methods of the separation of isotopes, thermodynamics, absorption, and other topics.

The mighty growth of the energy base of the Soviet Union all the more enlarges the field of electricity, and the preparation of personnel . . . is done by the department of electrochemistry.

The rapid development of polymers and their broad use in all fields of the national economy gives real meaning to the work of the department of high molecular weight compounds.

The chemistry faculty has day and night departments. The student plan of the day division takes 5.4 years, and the night class takes five years and ten months.

The study plan of the chemistry faculty provides all students with study in the following basic disciplines: inorganic chemistry, organic chemistry, analytical chemistry, physical chemistry, chemical technology, the structure of substances, colloid chemistry, polymer chemistry, the history of chemistry, higher mathematics, general physics, theoretical physics, crystallography, political economics, dialectical and historical materialism, the history of the Communist Party of the Soviet Union, a foreign language, and a few others. All study plans include a considerable number of hours of laboratory work, in which students learn

[1] Present address: 1810 Shuey Avenue, Walnut Creek, California. Prior to a postdoctoral year at Illinois, the author spent nine months doing postdoctoral research in the chemistry faculty of Moscow State University (USSR), under the auspices of the 1958 Cultural Exchange Agreement between the governments of the USA and USSR. The student exchange program was supervised by the Inter-University Committee on Travel Grants (Indiana University). The author's research was done in the *kafedra* of organic chemistry under the direction of Professor A. P. Terentyev.

[2] A rough transliteration is used for some Russian academic terms. *Faculty* is the equivalent to our department. A *kafedra* is a division in the department.

[3] The Academy of Sciences exercises rule over scientific research in the Soviet Union, and its institutes do the most important and extensive research. Five-sixths of all chemical papers appearing in Soviet journals are from the various institutes directly or indirectly related to the Academy; the nuiversities together produce the remaining one-sixth.

[4] K. I. Ivanova (editor), *Spravochnik dlya postupayushchikh v MGU v 1960 godu.* (Reference Book For Persons Entering Moscow State University in 1960) (Moscow, 1960).

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the basic methods and experimental techniques of chemical research. In the higher courses, the students work in the laboratories of the specialty of their choice.

After 3.5 years, some practical training is given concerning industrial practices in the chemical industry, after which period the students return to the studies of their own specialties and the fulfillment of their diploma work.

After finishing the faculty, they are sent to work in chemical laboratories in factories and research establishments.

The active participation of all members of the large staff of the chemistry faculty insures top quality training of chemists at Moscow University. This high level of training is necessary for meeting the tasks in the field of chemistry in compliance with the directives of the Twenty-first Congress of the Communist Party of the Soviet Union.

The head of the chemistry faculty is Profesfor K. V. Topchieva.

The most striking feature of the material quoted above is the "production" concept. The chemistry faculty seems to consider itself a factory turning out a finished product after several manipulations of a raw material. This picture is correct and consistent with many other features of de-individualized Soviet society. Exactly where this product will go, however, is not always easy to ascertain. Most graduates go to research institutes, where they work as research technicians (loosely similar to laboratory assistants in our industrial research laboratories). The others continue at academic institutions. The movement between research institutes and academic institutions is not completely reversible; above the undergraduate level, moving to an institute from a university is far easier than moving from an institute to a university. Generally, the Soviet university emphasizes teaching; and the Soviet institute, research.

Research in the chemistry faculty is claimed to be determined by "decisions of the Communist Party with respect to the development of the chemical industry and the national economy in general." While statements to that effect by the chemistry faculty seem to indicate an industrial bent, in actual fact little industrial research is pursued at the university. Indeed, research at Moscow State University is similar to the academic research we have in the United States.[5]

The staff of the chemistry faculty numbers about forty full professors, with approximately the same number of *prepodavately*, the Russian counterpart of our university instructor. Some of the older full professors would have been retired years ago in the West.

In general, one of the first impressions one has of Soviet students is their seriousness. The halls, cafeterias, and lounges of the chemistry faculty of Moscow State University are filled with quiet, purposeful youths. Although not as well-dressed nor as neat as college students in the United States, they seem, certainly, more serious and more dedicated than most American students. One is also impressed by the large number of females, about 60% of the chemistry students.

The seriousness and even a certain grimness are well justified. Soviet students devote a great amount of hard work and study to their schoolwork from the time they are seven until their graduation from high school. They have to score well on a difficult entrance examination in order to enter the chemistry faculty. The diploma at the end of their five-year course is the key to the beginning of a relatively comfortable life; but since the chemistry faculty is difficult, the student is always under pressure. The general opinion of most students with whom I talked was that the physics faculty was the most difficult and the journalism faculty was the easiest of the seventeen faculties.

It is almost impossible to determine the number of chemistry students at Moscow State University. The number is apparently very closely tied to the long-term plan for the country. I once asked the assistant head of the faculty how many chemistry students were enrolled. He answered that he did not know. When I then asked him *approximately* how many were registered, he answered that he was not sure and that he would rather not say. Some students, however, estimated the entering classes at about 300, with a dropout figure of $\sim 10\%$ at the end of five years.

Student Training

These 300 students were selected largely on the scores they had registered on the chemistry faculty's entrance exams, given in July at the same time entrance exams for all faculties are given all over the Soviet Union. About fifteen hundred persons take this examination for the chemistry faculty at Moscow State University. Somewhat less than half of these students are fresh out of high school; the rest are "experienced" people under 35 who had worked at least two years after having graduated from high school. The 1959 decree that two years of manual labor of some kind are now necessary before one can go on to an institution of higher learning does not seem to have significantly changed the profile of the group taking the examinations.

The entering chemistry freshmen have a good science background from high school. All high school students receive a considerable amount of training in chemistry, physics, and mathematics—more detailed and complete than that which we generally provide in our high schools. In organic chemistry, for example, the American student at most receives a brief, general introduction; in the Soviet Union, however, high school graduates are well aware of details such as benzene.

The entering group of three 300 students is broken down into approximately ten groups of 30 students each. These smaller groups, then, go through the first three years together as a unit. Classes in the faculty in the major, daytime, division are from nine in the morning to five in the evening five days a week, and from nine to three on Saturday. There is no hour for lunch, but 15–20 minutes are free each hour.

This means that the student is in class about six hours of the total eight-hour period. The length of the school year is nine months.

The first three years of the five-year course are identical for all students in the faculty. The first year consists mainly of inorganic chemistry (16 hours), plus eight hours of physics, five hours of a foreign language, five hours of mathematics, four hours of physical education, and three hours of the history of the

[5] This raises the question, "Just where is industrial research as we know it in the West performed?" Laboratories associated with factories themselves, such as the Moscow Vodka Factory, are of the quality control variety. Research and development apparently are mainly the responsibility of the institutes of the Academy of Sciences. Consulting, which is a rewarding supplement in the United States, seems to be an onerous task to be avoided in the USSR.

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Communist Party of the Soviet Union. The remaining five hours each week are taken up in a shop course and in "special courses." The second year emphasizes the study of analytical and physical chemistry. The third year is mostly organic chemistry.

It is at the fourth year that specialization begins. The student then has to select his narrow "specialty." For instance, he may decide he wants to be a physical chemist, specifically, to work in kinetics with Academician Semenov, or he may decide to become an organic chemist working in the realm of organo-metallics. While this decision should be made chronologically at least by the same year by our students, the Soviet student cannot easily reverse his decision; "once a kinetics chemist, always a kinetics chemist." (How free the student is in making his decision cannot be determined. Just as the size of the various classes in the faculty is pre-determined, the relative proportions of chemists are very likely pre-determined.)

The fourth year, then, is loosely tailored to individual needs. In his fifth year, the student works on his diploma work; this involves doing independent research on a scientific problem given him by his advisor, whom he had officially chosen near the end of his fourth year. The character of this work is almost identical to that of our graduate work in chemistry. A fifth-year student is roughly comparable to our first-year graduate student. The graduate who has a diploma, then, is probably near our student who has a master's degree.

With the diploma also comes one's job assignment. This means two or three years work as repayment to the State for one's education. (This is regarded by the Soviet students as natural and just.) Most Soviet graduates remain at their jobs indefinitely. Some after the work period attempt to continue in post-graduate study as an *aspirant*, or graduate student, to work for the next higher degree, *Kandidat* of Science. As a *Kandidat* he will receive additional money, enjoy greater prestige, and pursue his own research to some extent.

A person is admitted to the faculty to work for the degree of *Kandidat* on the basis of recommendations and of his score on the graduate student's entrance examination, which has the same form as the faculty entrance examination but is considerably more difficult. In recent years, the number of persons admitted has risen sharply. Formerly, about ten graduate students were admitted per year from about two hundred applicants. At present, about 50 are admitted each year.[6]

In chemistry, the *Kandidat* is about the equivalent to our Doctor of Philosophy. However, the *Kandidat* must publish at least two papers from his thesis before he can receive the degree. This is probably the main reason Soviet papers in chemistry are so short.

The highest degree is the doctor of science, which has no American equivalent. Ordinarily, it represents about ten years of outstanding scientific research after one has received his *Kandidat* degree and has published at least one substantial book.

[6] Considering all fields, we have about ten times as many graduate students as do the Russians. However, it is dangerous to generalize and draw conclusions from this fact alone, since we have many graduate students in fields where the Soviets offer no higher degrees. Also, Russian students are trained specifically for their life work, while Americans do not always use their education directly.

Research Conditions

Research conditions and attitudes at the faculty are considerably different from those at the chemistry departments of our major universities. Equipment is generally of the type found in our undergraduate laboratories, and work is therefore tedious by our standards. Russian chemical reagents are of a lower purity than ours. One tiresome consequence of inadequate chemical industry is the fact that one must conserve solvents. Any solvent stripped from a solution has to be collected, purified and used again. Oil baths and heating mantles are scarce, the main heat source is the Bunsen burner.

I should point out again that conditions in the institutes are apparently considerably better than in the universities. Whenever a complaint was made at the university about the scarcity or lack of a certain item, I was told, "Please, we are not an institute."

The organization of research is similar to that in other parts of the world, but authority and responsibility are highly concentrated in the hands of middle-aged or elderly men. Bright, young research chemists, those in their late twenties or early thirties, seem to resent this. Another source of frustration—to young and old alike—is the constant, almost insurmountable, red tape.

The worst feature of Soviet research, however, stems from the society in which the research is carried out. There is a great lack of free communication between workers. The isolation of the researcher seriously cuts off the development of scientific thought as we understand it. Ideally in the Soviet Union, research is done behind closed doors by one individual and his assistant. Spontaneous groups discussing chemistry are a vital feature of our research approach. In the Soviet Union, however, these groups rarely exist; consequently, most new techniques and fresh ideas have a far different and much slower genesis than in our country. Even at the highest levels, there seems to be little visiting among scientists in most fields. The national meetings of the American Chemical Society, a wellspring of stimulation and enthusiasm, have no counterpart in the Soviet Union, for instance.

Part of what has been said here has been derived from discussions with my fellow graduate students in the university chemistry faculty. My colleagues there all felt extreme pride in the scientific achievements of the USSR. They felt that Soviet organic chemistry is not the best in the world only because of the lack of equipment. In fact, they often claimed that modern organic chemistry was invented solely by a Russian. No amount of evidence or reasoning could soften this firm belief. This illustrates, I think, the error in the popular contention that, while statesmen and diplomats may differ, scientists can always come to harmonious agreement regardless of nationality. Scientists, being human, necessarily think in patterns largely determined by their environment.

Acknowledgment

The author wishes to express his gratitude to the Inter-University Committee on Travel Grants which made possible the year of study abroad (1959–60). In addition, he wishes to acknowledge helpful discussions with K. L. Rinehart, Jr.

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California Association of Chemistry Teachers

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What Is Humic Acid?

It was probably Berzelius who first asked the question: "What is humic acid?" more than 150 years ago. Since that time, hundreds of investigators have sought for an answer to this question. Although the literature is full of references to humic acid, precious little is known about the chemical structure of this ubiquitous soil constituent. Current investigations in a dozen research laboratories throughout the world are occupied with such problems as the isolation, structure, origin, and function of this dark-brown, amorphous substance.

Why is there such persistent scientific interest in a material which has yielded so little information, despite the many fruitless years of effort spent to probe its structure? No doubt, because it has been associated with soil fertility and agricultural productivity. Perhaps it may be one of the key substances in man's ceaseless search for a more abundant food supply. Perhaps the frustrating difficulties associated with its characterization constitute a sufficient challenge to keep stubborn investigators busy in their laboratories.

Humic acid is certainly no ordinary natural product. One does not simply extract it from a convenient reproducible source, crystallize it, determine its physical properties and empirical formula, and then proceed to determine its structure by the methods of modern organic chemistry. Like lignin or tannins, there exists no simple unique "humic acid." It is usually defined as that fraction of the soil organic matter which is soluble in dilute base but insoluble in mineral acid and alcohol. Like lignin and tannin, it is described in terms of its environment and its extraction procedure. For example, a typical sample would be described as "podzol humic acid, from a B soil horizon, extracted with 0.5 *M* NaOH under nitrogen." When one obtains a sample of humic acid by basic extraction from the soil, he is aware that the material may have been significantly modified by the extraction procedure; this is also a characteristic phenomenon in lignin chemistry.

Thus, when an organic chemist looks at humic acid, he must bear in mind that this substance may best be defined in terms of its origin and soil environment, rather than in rigid terms of chemical properties. In fact, criticism has been leveled (*1*) at chemists for oversimplifying the structural problems. Some investigators have claimed to have synthesized humic acids (brown, polymeric, base-soluble materials) by cooking carbohydrates in concentrated hydrochloric acid for prolonged periods of time (*2*) or by carrying out browning reactions between monosaccharides and amines (*3*). From these reactions, they have inferred that carbohydrates are the prime builders of humic acid. However, these experiments, as well as others, have been carried out under conditions alien to ordinary soil processes; and they have been justifiably criticized on this basis.

Although this article will be primarily devoted to a review of the chemical investigations of soil humic acid, the reader should understand that a complete characterization of this substance will depend also on the results of microbiological and pedological studies.

Origin

Humic acid occurs in rotting vegetable matter and can be detected in the black slime of an ordinary compost pit in a home garden. It is found in the brown organic matter of a variety of soils, as well as in peats, lignite, and brown coals. It is apparently formed by the bacterial and chemical degradation of plant tissue, but in soils it is most likely formed by certain secondary processes: polymerization of polyphenols leached by rain from surface leaf litter and condensation of phenols, quinones, and proteins which are provided by the action of soil micro-organisms and small animals on soil carbohydrates.

There is some evidence (*4*) that humic acid may be present in the plant, due to the microbiological decomposition of cell wall tissue, in the form of a soluble phosphate complex. Figure 1 summarizes the possible sources of humic acid (*5*).

Definition

As mentioned earlier, the commonly accepted definition of humic acid is "that portion of the soil organic matter which is soluble in base and insoluble in mineral acid and alcohol." Certain non-humic substances,

This article appears as a guest contribution to the CACT section at the invitation of the CACT Editor. Dr. Steelink was at one time associated with the laboratory of Prof. Norman Kharasch at the University of Southern California.

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such as polyuronic acids and complex proteins may also be separated from the soil by basic extraction procedures, as well as numerous metallic ions coordinated with humic acid. The use of strong base is objectionable on the ground that serious chemical transformations may take place during the separation procedure.

Conventional extraction techniques, therefore, employ dilute bases, such as cold 0.5 *M* NaOH, NaF or $Na_4P_2O_7$ in an atmosphere of nitrogen. Hydrogen fluoride has even been used, because of its ability to break humatesilica complexes, and thus put humic acid into solution.[1] Usually the soil is first treated with an alcohol/benzene solution to remove polyphenols, resins, and waxes. Ion exchange or dialysis techniques separate the major part of the inorganic constituents. Some investigators (*6*) prefer to use mild acid hydrolysis in order to remove the carbohydrate and protein fraction.

The definition of humic acid rests on an operational scheme. This may cause some concern among investigators who prefer the more precise language of organic chemistry (e.g., "white, crystalline solid, mp 51°C, etc.). However, reference to common descriptions of lignin (e.g., "Braun's native black spruce lignin; Western hemlock sulfuric acid lignin, etc.") are also imprecise in terms of classical chemical language. Nevertheless, this has not prevented the development of a considerable body of respectable chemical knowledge of the structure of lignin.

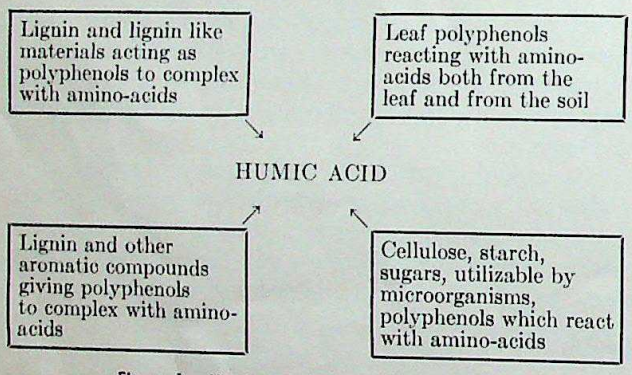

Figure 1. Humic acid formation in the soil (*5*).

Properties

Although the properties of humic acid will vary somewhat with soil origin and environment, there are certain characteristic features common to all specimens. The dark-brown material is a macromolecule and a polyelectrolyte, whose molecular weight has been estimated to range from 800 to 500,000; but whose most commonly cited molecular weight appears to be in the range $2.0–5.0 \times 10^4$ (*7*).

Of particular interest to soil scientists is the base exchange capacity and the complexing ability of humic acids. These properties are important in relation to soil stability and state of aggregation, transport of metal ions in the soil and through plant tissue, and stabilization of soil organic matter against microbiological attack.

The base exchange capacity, as measured by calcium acetate, ranges from 400 to 600 milliequivalents/100 grams of humic acid (*1, 8*). Evidence of chelate formation with metals of the transition group has been presented by Martin and Reeve (*9*). The property of complexing metals has been known for a long time; most soil humic acids have high ash contents, and are difficult to separate from these mineral constituents. Experiments with artificial soil mixtures have been carried out by Bloomfield (*10*) to illustrate the role of chelation in the formation of soil horizons. Thus, an insoluble iron-humate layer was formed several inches below the surface, when aqueous leaf extracts were poured over an iron oxide-celite mixture (Figure 2). The polyphenol solution reduced the iron(III) to iron (II) and the latter formed of dark-colored complex.

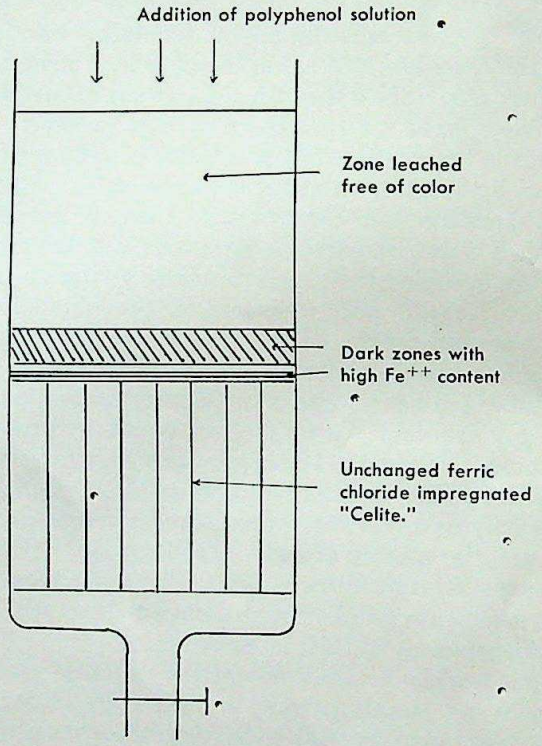

Figure 2. Model podzol produced by polyphenols (*10*).

Two curious side-lights of the complexing properties should be mentioned here. In the course of searching for a suitable soil to mix with cement for road construction, Clare and Sherwood (*11*) of the Road Research Laboratories in England, found that small amounts (less than 0.5%) of humic acid prevented the concrete mixture from hardening. Addition of calcium chloride to the mixture of cement and soil restored the ability to harden. The investigators attributed the loss of hardening to the complexing action of the humic material on calcium liberated by the hydration process.

Another unusual aspect of the complexing property is illustrated by the following incident. Some years ago, this author received a letter from an old Arizona "placer" miner, who had written in response to an article on humic acid in a local journal. In the letter, the miner claimed that secondary enrichment of some sedimentary gold deposits could be due to the chemical solution of gold and the subsequent deposition of the

[1] Some investigators have claimed that free, uncomplexed humic acid is water and alcohol soluble. Experience in our laboratory has supported this claim, since humic acid with low ash contents are definitely more soluble in alcohol or water than high-ash sample.

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metal downstream from the original source. The agent allegedly responsible for the solution was humic acid, which presumably complexed the metal under oxidative conditions. Subsequent reduction of the gold complex, as it was carried in a stream over reducing agents, would account for the enriched deposits.

The above process could be analogous to the solution of gold by the oxidative complexing of cyanide ion, as illustrated by the equations below.

$$Au + H^+ + \text{humic acid} + O_2 = Au(\text{humate})^{3+} + H_2O$$
$$Au(\text{humate})^{3+} + R = Au + \text{humic acid} + R^+$$
(R = reducing agent, such as Fe^{++} or organic compounds)

Literature references to this process are scattered (*12*) and conflicting, but indicate that such a role for humic acid has received serious attention.

In another recent communication to this author (*13*), it was reported that alkaline solutions of humic acid had dissolved native copper. Stevenson (*14*) and others have measured stability constants for various humic acid-metal complexes.

Attempts to characterize humic acid by infrared and ultraviolet absorption spectrophotometry have been unsuccessful. The infrared spectrum (Figure 3) contains a few sharp bands indicating hydroxyl and carboxyl functions, but the major part of the spectrum is featureless. Broad bands around 1600 cm^{-1} have been variously interpreted to represent carboxylate, quinoid, aromatic, and ethylenic moieties.

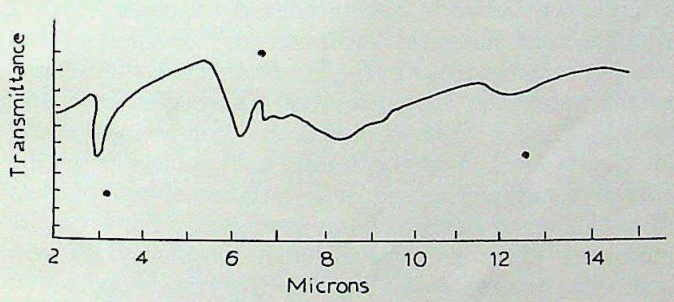

Figure 3. Infrared spectrum of humic acid (33).

The ultraviolet and visible spectra are monotonic, with no observable bands, and indicate only high absorption in the region below 400 mμ. Extinction coefficients have been used as a measure of degree of condensation by Kononova (*1*). Thus, she attributes high values of E^{465} to a polynuclear aromatic structure, and low values of E^{465} to structures with a high aliphatic content. This particular assignment has been consistent with another property of humic acid: its degree of dispersion as measured by coagulation experiments with electrolytes. The more highly aromatic structures have a higher degree of dispersion. It can readily be seen that this property of humic acid is of great interest to soil scientists, since degree of dispersion could affect many soil processes, including mobility of soil-mineral complexes, formation of soil structure, and translocation of humic substances in a soil profile.

In common with lignins, humic acids from different sources vary somewhat in their elemental composition. This is illustrated in Table 1.

Particular attention has been directed to the nitrogen content, which may vary from 0.5 to 5%, but which most commonly occurs in the range 3–5%. Bremner (*16*) and others have investigated the nature of the nitrogen compounds and have found that up to 75% of the nitrogen may be amino-acid (presumably from bound protein material) and glycosamines. On the other hand, some humic acids contain up to 75% unhydrolyzable nitrogen; in these acids, the element appears to have been irreversibly incorporated into the macromolecule and to exist in heterocyclic moieties (*17*). Interest in the nature of the fixed nitrogen is based on the possible role of humic acid as a denitrifying agent in the soil. *In vitro* experiments with natural and artificial humic acids (*18*) have shown that nitrite, ammonia, and amino acids can be irreversibly fixed under oxidative conditions. Since the amount of nitrogen reserve (fixed form) in the soil is a very important agricultural quantity, interest in the chemistry of N-containing humic acids has been intense.

Many investigators have used the C/H ratio of humic acids as a measure of the degree of condensation of aromatic rings, or as a measure of the state of oxidation; regular trends have been observed in certain types of acids, for example from podzol humic acids to chernozem humic acids. There have been some attempts to use this as an index for a rational classification of soil humic acids.

Chemical Studies

Should a young, ambitious PhD in organic chemistry examine this description of humic acid, the chances are that he would not be enticed to work with the compound. He would see a poorly-defined substance of varying elemental composition which was polymeric and non-crystalline. Furthermore, if he surveyed the literature carefully, he would find chemical references of countless papers dating back more than one hundred years. Very few of these references would contain any significant structural information about the compound. A formidable assignment would face the hardy or stubborn scientist who would willingly forego the opportunity of tackling a productive organic problem to work with humic acid.

Yet, there is a small number of chemists who are now actively investigating the structure of this substance. Most of those who have devoted their time and energy to probing the structure of this intractable material are associated with soil institutes in Russia, Germany, and Great Britain; relatively few Americans and Canadians are currently active in this field.

Chemical studies of humic acid fall into two broad categories: functional group analysis and degradative experiments. By the use of titration, acetylation,

Table 1. Elementary Composition of Humic Acids from Various Soils (*1*)

Soil	C	H	N	C/H
Podzolic	52.39	4.82	3.74	10.9
Rendzina	54.90	4.36	4.07	12.6
Degraded chernozem	56.34	3.54	3.58	15.9
Deep chernozem	57.47	3.38	3.78	17.0
Ordinary chernozem	58.37	3.26	3.70	17.9
Chestnut soil	58.56	3.40	4.09	17.2
Podzolic soil	56.67	4.79	5.14	11.8
Forest podzol B	52.77	3.62	0.51	14.6[a]

[a] See reference (*15*).

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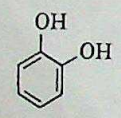
and methylation procedures chemists have shown the presence of carboxyl, phenolic, and aliphatic hydroxyl groups. Some evidence has been presented also for carbonyl and quinoid functions. An example of such a functional group analysis for a forest podzol-B soil humic acid is given in Table 2 below:

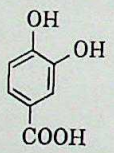
Table 2. Functional Groups in Humic Acid (*19*)

Functional group	Millieq. per gram of dry ash-free acid
Total acidity	11.5
Carboxyl	8.6
Total hydroxyl	5.1
Phenolic hydroxyl	2.9
Alcoholic hydroxyl (total-phenolic)	2.2
Carbonyl	5.5
Methoxyl	0.2

Both oxidative and reductive degradations have been carried out with humic acid, in both acid and basic media. Prior to the use of paper chromatography in the past ten years, relatively few degradation products were isolated and identified. These were mainly derived from catechol (I), protocatechuic acid (II), and benzene polycarboxylic acids (III). These compounds are typical breakdown products of lignin and are also found in coals.



I



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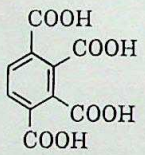
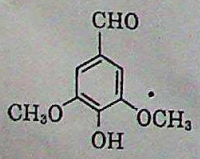


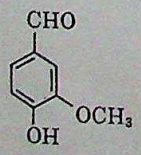
III

Most of the early chemical studies were carried out under drastic conditions, such as KOH fusion, oxidation with boiling nitric acid, and oxidation with alkaline permanganate. Under such conditions, extensive destruction of the substance occurred, and only 1–2% of the original compound could be recovered as recognizable monomers. Even many of the monomeric phenols and phenolic acids had suffered radical changes under some of the reaction conditions.

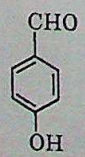
Recently, milder conditions have been employed in an attempt to recover molecular species which bear some resemblance to their original structure in the humic acid molecule. These newer techniques, coupled with paper chromatography, have enabled investigators to isolate a number of components in complex reaction mixtures. Thus, Morrison (*20*) in 1958, utilizing the alkaline nitrobenzene oxidation procedures (commonly employed in lignin chemistry), found syringaldehyde (IV), vanillin (V), and *p*-hydroxybenzaldehyde (VI) in low yields (less than 2%) in peat humic acids.



IV

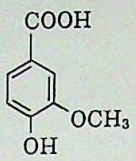


V

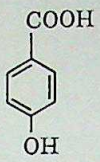


VI

Later, Steelink and Green (*21*), using the CuO-NaOH oxidation method, isolated the same compounds as Morrison had, plus the corresponding acid derivatives, vanillic acid (VII) and *p*-hydroxybenzoic acid (VIII). All of these compounds would be expected to

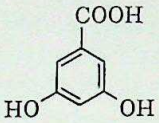


VII

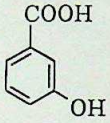


VIII

arise from the chemical breakdown of lignin. What was novel in the results of Steelink and Green was the detection of two additional phenolic acids, 3,5-dihydroxybenzoic acid (IX) and meta-hydroxybenzoic acid (X), in the reaction mixture containing compounds (IV) through (VIII).

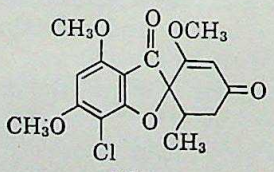


IX

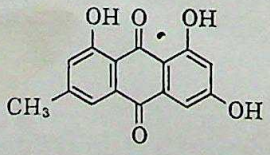


X

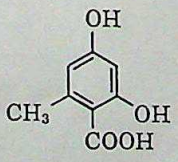
Clearly, compounds (IX) and (X) could not arise from lignin under the reaction conditions which were employed and must be assumed to be derived from resorcinol moieties in the humic acid molecule. This was the first chemical evidence for the existence of non-lignin components in the humic acid macromolecule, a fact which had been previously suspected by many investigators. Resorcinol-derived compounds could be incorporated into the humic acid molecule by the oxidative polymerization of a number of polyphenols (*5*) which occur in the soil environment. For example, numerous plant extractives such as pinosylvin and quercetin possess resorcinol hydroxylation patterns; many microorganisms also synthesize compounds based on resorcinol, such griseofulvin (XI), emodin (XII), and orsellinic acid (XIII). Since these compounds, or



XI



XII



XIII

their degradation products, could co-exist with lignin compounds in the soil, their copolymerization into the humic acid polymer is not unlikely.

Indole-derived substances (XIV) have also been detected by chromatographic techniques in nitrogen-containing humic acids by Flaig (*17*), indicating that part of the nitrogen is irreversibly fixed in a heterocyclic

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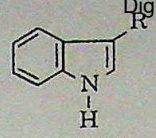


XIV

system. Other workers (*22*) have analyzed the acid-hydrolyzable fraction of humic acid and have found 22 amino acids in addition to a variety of aminosugars.

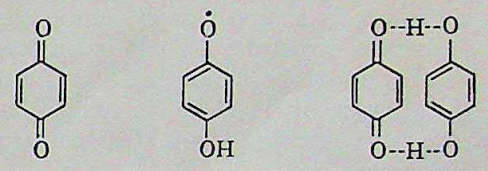
If one surveyed the present-day knowledge of the chemical structure of humic acid, he would conclude that it is a macromolecule in the molecular weight range of 20,000–50,000 which contains an easily hydrolyzable protein and carbohydrate fraction attached to a highly condensed "core." This "core" is partly aromatic in character, with structural elements derived from lignin phenols and resorcinol phenols. In addition, alcohol, carboxyl, carbonyl, and quinoid groups are present, together with heterocyclic nitrogen. The substance is invariably complexed with 1–20% inorganic matter.

Because of the difficulty inherent in direct chemical studies of this substance due to extensive destruction into uncharacterized fragments, other approaches have been attempted. Flaig in Germany (*23*) and Erdtman in Sweden (*24*) have studied the oxidative polymerization of simple phenols into brown, artificial "humic acids," in an attempt to simulate natural processes in the soil. A proposed model for the formation of humic acid, based on extensive studies with model systems, is in Figure 4.

While most investigators have accepted the lignin origin of humic acid, microbiologists have challenged this assumption. Kononova in Russia (*26*) has shown that *aspergillus* and *penicillium* molds produce humic-like substances when grown on glucose. R. J. Swaby in Australia (*27*) has proposed that humic substances are formed by the rapid copolymerization of simple phenols in dead plant cells, and not by the slow decomposition of lignin. Such a view has received support from the findings of Raudnitz (*4*) who showed evidence for the presence of humic acid-phosphate complexes in the leaves of rhododendrum species.

Although studies of the biogenesis of humic acid are important and necessary, they cannot be definitive until more direct information is available about the molecular structure. The primary task of the organic chemist still remains: to discover techniques which will provide this information without destroying a major portion of the molecule in the process. Two recent developments in the field show promise of meeting this requirement. One is the reductive pyrolysis of humic acid in the presence of steam, a process which tends to preserve the structural integrity of quinoid and other labile systems, which are normally fragmented or polymerized under strong oxidative conditions. Feldbeck, at the University of Delaware (*28*), has analyzed the volatile products of this pyrolysis reaction by means of vapor phase chromatography. He has been able to account for more than 30% of the original weight of humic acid as phenolic constituents. Hopefully, such studies should provide a much more complete picture of the variety of components in the macromolecule than is now available.

A second technique is based on the observation by Rex (*29*) that humic acid is a stable free organic radical. Using electron paramagnetic resonance spectrometry, Steelink and Tollin (*30*) at the University of Arizona have carried out a series of measurements to determine the nature of this free radical. Quite recently, the Arizona group (*31*) has been able to deduce certain structural elements in humic acid by observing the change in the EPR spectra as a function of chemical reduction. The spectra very clearly resemble that expected from a mixture of quinones (XV), semiquinones (XVI), and quinhydrones (XVII). If humic



XV XVI XVII

acid were derived in part (or totally) from lignin phenols, then these results would indicate that these phenolic elements have suffered bacterial or chemical oxidation. The same reasoning would apply to resorcinol-derived compounds, since these too are capable of being oxidized to stable free radicals. If Flaig's assumptions (Figure 4) are reasonable, then compounds (XV), (XVI), and (XVII) would be expected to arise from the oxidation of lignin.

The task that remains in this area is to determine the exact nature of these suspected quinone species and to determine their concentration in the macromolecule. Future EPR studies with controlled reduction and oxidation should provide a basis for the quantitative estimation of these moieties.

It is interesting to note that the occurrence of stable free radicals is quite consistent with the proposals of other workers regarding the biosynthesis of humic acid by the oxidative polymerization of phenolic substances. Two common natural polymers, lignins and melanins, also possess stable free radicals; the exact

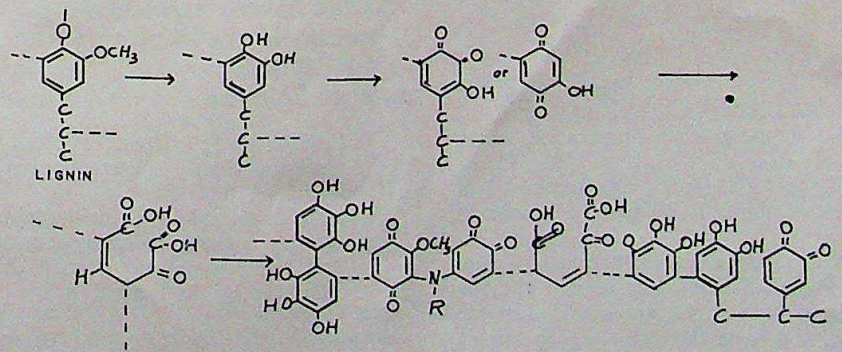


Figure 4. Possible formation of humic acid from lignin (25).

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nature of the system which stablizes these free radicals is not known, but semiquinone structures which provide sufficient delocalization of the unpaired electron are most consistent with present evidence. All three of these substances have their origin in naturally-occurring polyphenols.

Conclusion

While the answer to the question "What is Humic Acid?" is still only fragmentary, newer chemical techniques for elucidating structural features are currently adding to the present knowledge of the subject. Information will also come from related disciplines as well as from the studies of related compounds. Microbiologists in Germany and Switzerland have recently carried out experiments with rotting wheat straw, which suggest that the bacterial decomposition of lignin leads directly to humic acid (*32*). Other investigators (*1*) have concentrated on the fulvic acid fraction of soil organic matter (that material extracted with dilute base, which is soluble in mineral acid) on the assumption that this substance is a precursor of humic acid and also has a simpler structure. These scientists hope to gain insights into the humic acid structure by studying the simpler fulvic acids, in much the same manner that lignin chemists have studied the structures of the simpler lignans.

No doubt, the vast majority of organic chemists will choose greener pastures to investigate in preference to working with a substance which is so poorly defined and so poorly characterized as humic acid. The few chemists who persist in the field, however, can take heart at the progress which has been made in the last forty years with natural polymeric substances of equally frustrating properties—lignins, tannins, proteins, viruses—and continue to probe for information which will eventually provide a rational solution. Impetus to seek this solution also comes from the ever-increasing commercial uses of humic acid, such as drilling muds, boiler scale removal, pigments for printing inks, and fertilizers, as well as the increasing number of reports of its growth-hormone activity for plants and its role in transport of trace minerals.

Finally, out of sheer cussedness, there will always be a few hardy souls who will want to know the fundamental reason for Nature's wide distribution of this substance, and the method by which she synthesized it.

Literature Cited

(1) Kononova, M. M., "Soil Organic Matter," Pergamon Press, New York, 1961.
(2) Berthelot, M., and Andre, G., *Compt. Rend.*, **112**, 916 (1897).
(3) Maillard, L. C., *Ann. Chim. Phys.*, **9**, 258 (1917); Stevenson, F. J., *Soil Sci. Soc., Amer. Proc.*, **24**, 472 (1960); and Hodge, J. E., *Agric. and Food. Chem.*, **1**, 928 (1953).
(4) Raudnitz, H., *Chem. & Ind.*, **1957**, 1651.
(5) Davies, R. I., Coulson, C. B., and Lewis, D. A., *Sci. Proc. Roy. Dublin Soc.*, Series A, Vol. 1, 183 (1960).
(6) Forsythe, W. G. C., *Chem. & Ind.*, **1948**, 515.
(7) Piret, E. L., White, R. G., Walther, H. C., Jr., and Madden, A. J., Jr., *Sci. Proc. Roy. Dublin Soc.*, Series A, Vol. 1, 69 (1960).
(8) Mukerjee, H., *J. Ind. Chem. Soc.*, **33**, 744 (1956).
(9) Martin, A. E., and Reeve, R., *J. Soil Sci.*, **9**, 89 (1958).
(10) Bloomfield, C., *J. Sci. Food. Agric.*, **8**, 389 (1957).
(11) Clare, K. E., and Sherwood, P. T., *J. Applied Chem.*, **6**, 317 (1956).
(12) Freise, F. W., *Econ. Geology*, **26**, 421 (1931); Fetzer, W. G., *Econ. Geology*, **41**, 47 (1946).
(13) Tinsley, J., Department of Soil Science, University of Aberdeen, Scotland, Private communication.
(14) Stevenson, F. J., and Khanna, S. S., *Soil Sci.*, **93**, 298 (1962).
(15) Steelink, C., Berry, J. W., Ho, H., and Nordby, H., *Sci. Proc. Roy. Dublin Soc.*, Series A, Vol., 1, 59 (1960).
(16) Bremner, J. M., *J. Agric. Sci.*, **46**, 247 (1955).
(17) Flaig, W., and Breyhan, Th., *Z. Pflanzenernaehr., Dueng., Bodenk.*, **75**, 132 (1956).
(18) Bremner, J. M., *J. Agric. Sci.*, **48**, 352 (1956); Brusset, H., and Charpin, P. *Compt. Rend.* **240**, 2315 (1955).
(19) Schnitzler, M., and Wright, J. R., *Nature*, **184**, 1462 (1959).
(20) Morrison, R. I., *J. Soil. Sci.*, **9**, 130 (1958).
(21) Steelink, C., and Green, G., *J. Org. Chem.*, **27**, 170 (1962).
(22) Bremner, J. M., and Shaw, K., *J. Agric. Sci.*, **44**, 152 (1954); Bremner, J. M., *J. Sci. Food Agric.*, **9**, 528 (1958).
(23) Flaig, W., *Sci. Proc. Roy. Dublin Soc.*, Series A, Vol. 1, 149 (1960).
(24) Erdtman, H., and Stjernstrom, N. E., *Chem. & Ind.*, 1599 (1960).
(25) Flaig, W., *Suomen Kemistilehti* A., **33**, 229 (1960).
(26) Kononova, M. M., and Aleksandrova, I. V., *Soils & Fertilizers*, **22**, 77 (1959).
(27) Swaby, R. J., CSIRO, Division of Soils, Adelaide, Australia, private communication.
(28) Feldbeck, G. T., *Chem. Eng. News*, Dec. 11, 1961.
(29) Rex, R. W., *Nature*, **188**, 1186 (1960).
(30) Steelink, C., and Tollin, G., *Biochim. et Biophys. Acta*, **59**, 25 (1962).
(31) Steelink, C., Reid, T., and Tollin, G., *Chem. Eng. News*, Sept. 24, 1962.
(32) Flaig, W., Schobinger, U., and Deuel, H., *Chem. Ber.*, **92**, 1973 (1959).
(33) Elofson, E. M., *Can. J. Chem.*, **35**, 926 (1957).

More Basic Precepts of Science

Serendipity. "Luck" is what happens when preparation meets opportunity.

The Detergent Dilemma. The lot of the successful chemist is a lifetime of (1) asking questions and (2) washing glassware afterward.

The Statistician's Preamble. As the correlation between prediction and observation passes 0.75 and heads toward 1.0, the competent scientist will pause and ask one vital question: "Is the data being tabulated from the same experiment as the one on which the prediction was based?"

The Pedagogue's Practicum. You can no more teach what you do not know than you can come back from where you have not been.

Gumperson's Second Law. In the laboratory, attention should be directed toward increasing that commodity indicated by the first five letters and toward diminishing that commodity indicated by the last seven.

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Report of the **New England Association of Chemistry Teachers**

Gene B. Carpenter
Brown University
Providence, Rhode Island

The Use of *n*-Center Bonds

The concept of the n-center bond is a straightforward extension of the concept of the ordinary covalent bond, one which has generally received slight attention and inadequate publicity. Yet it proves to be simple, natural, and useful. It will be demonstrated how three- and four-center bonds especially provide a unified pattern for describing the bonding in many situations where the usual two-center electron pair bonds are inadequate. These include the triiodide ion, the new inert gas compounds, hydrogen bonds, some transition states, and many others.

The concept is closely related to the conventional molecular orbital description of π-bonds in conjugated systems, which may indeed be included as cases of the n-center bond, although they will not be discussed here. Cyclic cases are also omitted from this discussion.

The important three-center four-electron case was worked out some time ago by Hach and Rundle (*1*) for I_3^- and by Pimentel (*2*) for FHF^- and I_3^-. It has very recently been used by a number of workers, especially Rundle (*3*), to describe the inert gas compounds, and Pitzer (*4*) has emphasized that the xenon fluorides and halogens fluorides can be all described in this way. Although Rundle (*5*) and others have applied such ideas extensively, it appears that their scope is not yet generally recognized.

In the following section, the quantum mechanical basis of the n-center bond is summarized, and some of its qualitative features are deduced. Then a variety of illustrative applications are presented.

The Quantum Mechanical Basis

The general system under discussion is a set of n atoms along a chain. Suppose that each atom has available one atomic orbital, not otherwise engaged, for possible bond formation. Then n molecular orbitals may be constructed in the form of linear combinations of the n atomic orbitals, such that one has minimum energy. Finally, the available electrons are assigned in pairs to the lowest-energy molecular orbitals. Then an estimate may be made of the total energy of the electrons relative to that which they would have in uncombined atoms or in smaller molecules. If the energy in the n-center molecular orbitals is significantly lower, a bond has been formed.

For a drastically simplified model subjected to even more drastic approximations, the mathematical procedure is routine; yet this treatment is adequate for a useful qualitative understanding. The simplifications of the model are that the n atoms are alike and equally spaced. The approximations are those usual in the simplest molecular orbital approach: that one-electron molecular orbitals combine to yield a reasonable approximation to the true wave function for the system, that the atomic orbitals are orthogonal, that nearest neighbor interactions only are important, and that coulomb and exchange integrals are not sensitive to the value of n.

The results for $n = 1, 2, 3$, and 4 are set out in Table 1. Here E is the energy of the molecular orbital ψ; α and β are coulomb and exchange integrals, respectively; and $\phi_1, \phi_2, \ldots$ are the original atomic orbitals contributed by atoms 1, 2, ... For the purposes of this discussion numerical values of α and β are not required; but it avoids confusion to note that β is negative, so that the lowest entry for given n denotes the lowest energy.

The energy of a certain number of electrons in a system of n centers can then be approximated. The exclusion principle permits no more than two electrons per molecular orbital; for the ground state the electrons fill the lowest-energy orbitals as far as necessary. When more than one electron is present, the positive energy of repulsion between the electrons must be added to the sum of the orbital energies for the electrons.

Table 1. *n*-Center Molecular Orbitals

n	E	ψ
1	α	ϕ_1
2	$\alpha - \beta$	$0.71\,(\phi_1 - \phi_2)$
	$\alpha + \beta$	$0.71\,(\phi_1 + \phi_2)$
3	$\alpha - \sqrt{2}\beta$	$0.50\phi_1 - 0.71\phi_2 + 0.50\phi_3$
	α	$0.71\,(\phi_1 - \phi_3)$
	$\alpha + \sqrt{2}\beta$	$0.50\phi_1 + 0.71\phi_2 + 0.50\,\phi_3$
4	$\alpha - 1.62\beta$	$0.37\phi_1 - 0.60\phi_2 + 0.60\phi_3 - 0.37\phi_4$
	$\alpha - 0.62\beta$	$0.60\phi_1 - 0.37\phi_2 + 0.37\phi_3 - 0.60\phi_4$
	$\alpha + 0.62\beta$	$0.60\phi_1 + 0.37\phi_2 + 0.37\phi_3 + 0.60\phi_4$
	$\alpha + 1.62\beta$	$0.37\phi_1 + 0.60\phi_2 + 0.60\phi_3 + 0.37\phi_4$

Presented in part at the Meeting of the New England Association of Chemistry Teachers, Providence, Rhode Island, February, 1963.

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For the familiar $n = 2$ case, the process of bond formation from atoms may be written as $2A\cdot \rightarrow A{:}A$. Before bonding, the two electrons occupy separate atomic orbitals of energy α, after bonding, both electrons occupy the lower two-center orbital of energy $\alpha + \beta$. Thus the energy change including the repulsion energy E_r is $\Delta E = 2(\alpha + \beta) + E_r - 2\alpha = 2\beta + E_r$. Typically β is large and negative while E_r is positive; empirically the change ΔE is negative so that a stable bond is formed. Thus the existence of the usual two-center two-electron bond verifies that E_r is not the dominant term.

If a hypothetical situation is examined in which more electrons must be accommodated in the two-center orbitals, they must fill the orbital of energy $\alpha - \beta$. Then for the process $2A{:} \rightarrow A{::}A$,

$$\begin{aligned}\Delta E &= 2(\alpha + \beta) + 2(\alpha - \beta) + E_r - (4\alpha + E_r') \\ &= E_r - E_r'\end{aligned}$$

where E_r is now the repulsion energy among four electrons in the two-center system and E_r' is that for electron pairs on two atoms. From physical reasoning, ΔE should be positive or at least not appreciably negative, so no stable bond forms.

Molecules with odd numbers of electrons may be considered similarly; they are rare because of high reactivity rather than because of lack of stability with respect to atoms.

The only important two-center case is thus the familiar two-electron bond. It is important to note that the number of electrons in the bond equals the number of atomic orbitals employed.

A similar discussion of the three-center orbitals shows that both two- and four-electron bonds may occur. Two electrons can occupy the lowest orbital, giving

$$\begin{aligned}\Delta E &= 2(\alpha + \sqrt{2}\beta) + E_r - 2\alpha \\ &= 2\sqrt{2}\beta + E_r\end{aligned}$$

for the process $2A\cdot + A \rightarrow A\cdot A\cdot A$. In comparison with a two-center bond, β and E_r should be similar, so that the bond should be somewhat stronger than a two-center bond.

Two more electrons can be accommodated in the middle-energy orbital to give, for the process

$$2A\cdot + A{:} \rightarrow \cdot A\cdot A\cdot A\cdot,$$

$$\begin{aligned}\Delta E &= (2\alpha + \sqrt{2}\beta) + 2\alpha + E_r - (2\alpha + 2\alpha + E_r') \\ &= 2\sqrt{2}\beta + E_r - E_r'.\end{aligned}$$

Now $E_r - E_r'$ should be roughly similar to the repulsion energy for the two-electron case, so again a strong bond results. Assuming little difference in the repulsive energies, this four-electron bond should be more stable than $A{:}A + A{:}$.

A useful conclusion may be drawn from the form of the middle-energy orbital, $\phi_1 - \phi_3$. This shows that the two electrons which it accommodates reside chiefly on the end atoms. Consequently, it is reasonable to expect that this orbital will become more electronegative. This feature is implied by the suggested electron-dot notation for two- and four-electron bonds, $A\cdot A\cdot A$ and $\cdot A\cdot A\cdot A\cdot$. In Rundle's notation (*3*), these would be designated $3c-2e$ and $3c-4e$, respectively.

The energy of the remaining three-center orbital is too high to permit the formation of a stable six-electron bond.

In the $3c-2e$ bond, the number of bonding electrons is less than the number of atomic orbitals employed; it should therefore be expected in electron-deficient compounds, where there are too few electrons to form ordinary two-center bonds. In the $3c-4e$ bond, the number of bonding electrons is greater than the number of atomic orbitals; it should be expected in compounds where there are too many electrons to form two-center bonds.

Application of this line of argument to four-center orbitals shows that bonds with two, four, and six electrons may be stable with respect to atoms. The two-electron case, however, represents an electron deficiency too extreme to be expected in stable molecules. The four-electron case may not be appreciably stable with respect to two separate two-center bonds because of increased repulsion energy. The six-electron case will be rather weak but comparable to $A{:} + A{:}A + {:}A$, so it may come into play when this atomic arrangement is set up by other forces. From consideration of the orbitals occupied, the $4c-6e$ bond can be written $A\cdot\cdot A{:}A\cdot\cdot A$.

In general it may be expected, for cases with n greater than four, that the n-center bonds will be important only when other forces hold the n atoms in suitable positions. This is precisely the situation for π-electron systems.

In all cases the participating atomic orbitals may be hybrids but will usually approximate p-orbitals. It is clear that these will overlap most effectively if all are aligned along the bond axis. The resulting orbitals are sketched schematically in Figure 1 where for each case the orbitals are arranged in the same energy sequence as in Table 1. Hence both $3c$ and $4c$ bonds will be linear except where other bonds or steric considerations enforce a distortion. Furthermore, both kinds will make angles of roughly 90° with other bonds involving the same atoms.

Examples

The following list presents a number of cases where $3c$ and $4c$ bonds occur; it is merely illustrative of the range of applicability. Only the $3c$ or $4c$ bonds are

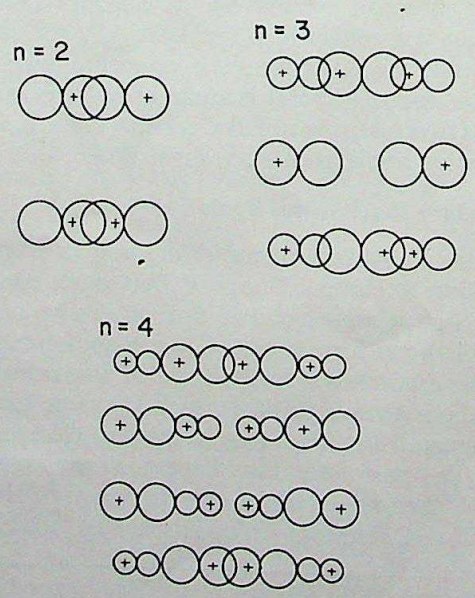

Figure 1. Schematic pictures of molecular orbitals for two, three, and four centers.

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shown explicitly; an additional number of unshared electron pairs, sufficient to complete the octet, is assumed around each atom. References are given only for recently published structure determinations. Many of the examples of interhalogen compounds and halides are described, and discussed in a similar spirit, in a recent comprehensive review (*6*).

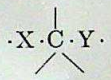
The $3c-4e$ bond appears most frequently.

I_3^-	·I·I·I·	Linear
ClF_3	·F·Cl·F·	T-shaped

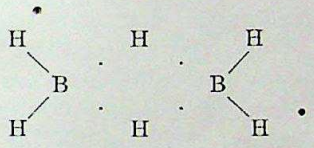
The implied difference in Cl-F distances is correct (*7*).

XeF_2	·F·Xe·F	Linear
XeF_4	F ·F·Xe·F· F	Square planar (*8*, *9*)
XeF_6	F F ·F·Xe·F· F F	Octahedral

The transition state in nucleophilic displacement on carbon can be described in terms of a $3c-4e$ bond



The $3c-2e$ bond occurs in electron-deficient compounds.



One such bond lies above the molecular axis, the other below; the geometrical constraints require the bonds to be bent.

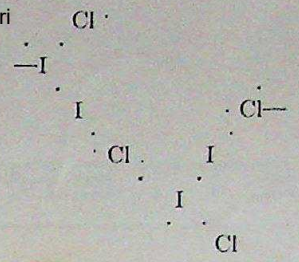
Al_2Cl_6 exhibits the same bonding pattern as B_2H_6 except that *p*-orbitals on the bridge atoms are employed.

Intermolecular Attractions

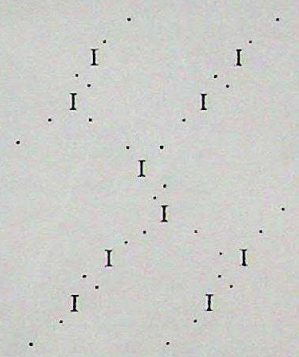
Both $3c$ and $4c$ bonds appear to provide useful descriptions of several kinds of relatively strong intermolecular attractions.

The hydrogen bond can be formulated as a $3c-4e$ bond, ·X·H·Y·. This description makes it clear why X and Y must be highly electronegative for a strong hydrogen bond, and why the angles made with other bonds on both X and Y (acceptor as well as donor) are normal bond angles. The qualitative concept does not easily explain the unsymmetrical nature of the hydrogen bond in a symmetrical environment as in ice; this must be lost by the crudeness of the quantum mechanical treatment.

In both α and β crystal forms of ICl, the molecules are somehow linked into infinite zigzag chains. The links can be interpreted as $3c-4e$ bonds. In β-ICl for example (*10*), the pattern is

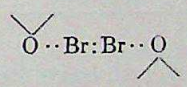


In some other solid halogens and halogen addition compounds, the $4c-6e$ bond appears to be significant. The simplest example is solid iodine, where the molecules occur in layers of the following type:



This description is essentially a qualitative version of an approximation of Bersohn's (*11*) more elaborate molecular orbital treatment of solid halogens.

One of many addition compounds showing the same pattern is bromine-1,4-dioxane (*12*) where the bonding is



Conclusion

The concepts of three- and four-center bonds are simple extensions of the ordinary two-center bond concept. They have considerable qualitative usefulness in cases where two-center bonds are not sufficient. More detailed study of these bonds would appear profitable.

Literature Cited

(1) Hach, R. J., and Rundle, R. E., *J. Am. Chem. Soc.*, **73**, 4321 (1951).
(2) Pimentel, G. C., *J. Chem. Phys.*, **19**, 446 (1951).
(3) Rundle, R. E., *J. Am. Chem. Soc.*, **85**, 112 (1963).
(4) Pitzer, K. S., *Science*, **139**, 414 (1963).
(5) Rundle, R. E., *Record Chem. Progr.*, **23**, 195 (1962).
(6) Wiebenga, E. H., Havinga, E. E., and Boswijk, K. H., in "Advances in Inorganic Chemistry and Radiochemistry," Emeléus, H. J., and Sharpe, A. G., eds. Vol. 3, Academic Press, New York, 1961, pp. 133–69.
(7) Burbank, R. D., and Bensey, F. N., *J. Chem. Phys.*, **21**, 602 (1953).
(8) Claasen, H. H., Selig, H., and Malm, J. G., *Science*, **138**, 136 (1962).
(9) Ibers, J. A., and Hamilton, W. C., *Science*, **139**, 106 (1963).
(10) Carpenter, G. B., and Richards, S. M., *Acta Cryst.*, **15**, 360 (1962).
(11) Bersohn, R., *J. Chem. Phys.*, **36**, 3445 (1962).
(12) Hassel, O., and Hvoslef, J., *Acta Chem. Scand.*, **8**, 873 (1954).

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Chem Ed

LETTERS

To the Editor:

The article "Naming Chemical Elements in Chinese" (THIS JOURNAL, **40**, 44 (1963)) proved very interesting. There are slightly different phonetic symbols published in "*Hua Hsüeh Ming Ming Yüan Tsê*" ("Principles of Chemical Nomenclature," Ministry of Education, **1932**) on pages 3–7.

copper (*t'uŋ*)	tin (*si*)	gold (*tçin*)
mercury (*kuŋ*)	silver (*iin*)	lead (*tçien, yan*)
hydrogen (*t'siŋ*)	oxygen (*jaŋ*)	phosphorus (*lin*)
platinum (*pai*)	bromine (*çiu*)	uranium (*jiu*)
tungsten (*u=*)	arsenic (*san*)	

Names such as

Hydrogen	Oxygen	Nitrogen
水 素	酸 素	窒 素
shui su	*suan su*	*chih su*
Wasserstoff	*Sauerstoff*	*Stickstoff*

are Japanese names and have been discarded. The symbols on the left are more commonly written as on the right

Nitrogen	Nitrogen
淡 氣	氮 氣
tan ch'i	
tasteless gas	

similar to hydrogen and oxygen. The meaning is to moderate the oxygen action, not "tasteless."

CHEN TA TUNG

CHANG-HUA MIDDLE SCHOOL
TAIWAN, REPUBLIC OF CHINA

To the Editor:

The official names now established for mercury, radium, and germanium are:

Mercury	Radium	Germanium
汞	鐳	鍺

There is also one element which does not fall into any of Suter's categories

Silicon
硅
kuei

The name for silicon is pronounced *kuei*.

J. C. CHANG

UNIVERSITY OF CALIFORNIA
LOS ANGELES, CALIFORNIA

To the Editor:

Dr. Suter's article, "Naming Chemical Elements in Chinese," is quite informative and should be commended for bringing to the reader's attention how Chinese chemists have ingeniously translated chemical names.

As to the puzzle of the three character transliteration of "*jih-chi-tê*" (Fig. 7, p. 46) for germanium, it is apparently due to a misunderstanding on the part of Dr. Suter. Actually each of the three characters represents tentative single character transliterations for germanium. Thus "*jih*" and "*chi*" are phonetical translations of the first syllable of germanium. "*Tê*," on the other hand, is a nonphonetical transliteration using a metal radical and a symbol for Deutschland.

CHISUNG WU

UNION CARBIDE CONSUMER PRODUCTS COMPANY
CLEVELAND, OHIO

To the Editor:

Dr. Albert E. Finholt has sent me references to publications from St. Olaf College which I missed in my tabulations for the article "Maintaining and Sustaining Chemical Publications in Liberal Arts Colleges" (THIS JOURNAL, **39**, 585 (1962)). The eight publications which were listed on my worksheets from this institution were concentrated in four years. This accounts for my omitting St. Olaf from the list of colleges which had publications for five or more years.

The following data on publications from St. Olaf College should be added to the table on page 586 of the November 1962 issue: there were two publications in 1953, two in 1954, two in 1956, one in 1957, one in 1958, and three in 1960 for a total of eleven papers.

JOHN R. SAMPEY

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GREENVILLE, SOUTH CAROLINA

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BOOK REVIEWS

Principles of Organic Chemistry

T. A. Geissman, University of California, Los Angeles. 2nd ed. W. H. Freeman and Company, San Francisco, 1962. x + 854 pp. Figs. and tables. 16 × 23.5 cm. $9.75.

This book represents a fine effort to introduce current theories of reaction mechanism concomitantly with a substantial part of the factual information that has traditionally constituted an introductory course in organic chemistry. Where feasible, the reactions and properties of organic compounds are described as illustrative examples of general principles. Development of necessary principles and emphasis on mechanism entails slow progress through classical organic chemistry and leads to an overall presentation that is longer than most teachers are accustomed to offer for a one-year course.

Theoretical organic chemistry today is not sufficiently predictive to replace the teaching of specific reactions in many areas and a teacher must choose, within the limits of time and students' abilities, some compromise between a mechanistic and an empirical presentation. Professor Geissman's book is sufficiently comprehensive to allow considerable latitude in selection of a compromise.

The first 115 pages are devoted to background material. Topics covered include structural formulas, a survey of the common functional groups, theories of bonding, acid-base reactions and systematic nomenclature. Many students will have encountered most of these concepts in their general chemistry course, and this section can be covered rapidly. The organization of the main portion of the book follows the time-honored sequence of aliphatic, alicyclic, aromatic, and heterocyclic compounds. Failure to integrate aliphatic, alicyclic, and aromatic compounds may seem to forfeit one of the main simplifying advantages of a modern approach to organic chemistry. Material in the scope of natural products is well chosen and appropriate to the interests of students preparing for careers in medicine, biochemistry, and related fields. Industrial organic chemistry is rarely mentioned, but there is a brief chapter on polymers. A concluding chapter on determination of structure of organic compounds is inadequate because spectroscopic techniques are ignored.

The alkanes, alkynes and dyes are given sparse coverage but the variety of reactions included for other classes of organic compounds is entirely satisfactory. Yields to be expected from reactions are not indicated, and references to original literature or to supplementary reading are not included. A listing in an Appendix of 50 compounds whose preparation is described in "Organic Syntheses" is of little apparent value.

The discussions of reaction mechanisms are logical and thorough. Aromatic substitution reactions and substituent effects in benzene receive particularly detailed attention.

Stereochemistry, optical activity, stereospecific reactions, conformational analysis, quantum mechanics, resonance theory, and molecular rearrangements are well presented. Some contributions from the areas of kinetics, thermodynamics, and isotopic labeling are included. Infrared, ultraviolet, and nuclear magnetic resonance spectroscopy is not discussed.

The approximately 400 problems are straightforward and emphasize principles developed in the text. Answers to about half the problems are given in an Appendix.

Structural formulas and figures are well drawn and numerous. Oversights in proof reading are few and minor. The Index (about 2000 major entries) is adequate.

Professor Geissman's book will appeal to many teachers who are anxious to modernize their courses, and to many students who object to memorizing without inquiring into reasons.

W. B. Renfrow
Oberlin College
Oberlin, Ohio

Reviewed in This Issue

T. A. Geissman, Principles of Organic Chemistry

Harry F. Lewis, editor, Laboratory Planning for Chemistry and Chemical Engineering

Emil J. Margolis, Qualitative Anion-Cation Analysis: An Interpretative Laboratory Text of Semimicro Procedure in Basic College Chemistry

Carl J. Ballhausen, Introduction to Ligand Field Theory

J. Thewlis, editor-in-chief, Encyclopædic Dictionary of Physics. Volume 7, Stellar Magnitude to Zwitter Ion

J. Herbert Taylor, Molecular Genetics, Part 1

K. S. Spiegler, Salt Water Purification

A. R. Patton, Science for the Non-Scientist

Jacob Kleinberg, editor-in-chief, Inorganic Syntheses. Volume 7

John J. McKetta, Jr., editor, Advances in Petroleum Chemistry and Refining. Volume 6

Erwin N. Hiebert, Historical Roots of the Principle of the Conservation of Energy

Taito O. Soine and *Charles O. Wilson*, Rogers' Inorganic Pharmaceutical Chemistry

Laboratory Planning for Chemistry and Chemical Engineering

Edited by *Harry F. Lewis*, Institute of Paper Chemistry, Appleton, Wisconsin. Reinhold Publishing Corp., New York, 1962. xiii + 522 pp. Figs. and tables. 22 × 26.5 cm. $20.

The Committee on Design, Construction, and Equipment of Laboratories, Division of Chemistry and Chemical Technology, National Academy of Sciences–National Research Council, and especially its editor, Dr. Harry F. Lewis, have rendered a most valuable service to chemical education and the chemical industry in the preparation of this modern and very comprehensive guide for the construction of laboratory facilities.

The book is arranged in seven sections; each written by one or more competent contributors. Section A, Organization of Planning and Construction, deals with the technique for planning by the owner, the architect, suppliers, and builders, and delineates the responsibilities of each.

Section B is concerned with general considerations including site selection, materials of construction, and traffic patterns for the movement of personnel and materials.

Section C, entitled Specific Considerations, gives detailed information concerning plumbing, heating, ventilation, refrigeration, electrical services, and laboratory furniture.

Section D is concerned with health and safety factors and includes a consideration of waste disposal problems.

Section E, entitled Applications and Design, is concerned with modular arrangements, distribution of services, location of stock rooms, and special facilities, including shops and common denominator facilities, such as reception area, office arrangements, provision for secretarial services, conference, cafeteria, library, and similar areas used in common by all

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members of the organization. This is followed by an extensive chapter on special applications, including pilot plants, high and low level radioactivity facilities, hospital research facilities, animal quarters and equipment, high pressure laboratories, and controlled environment rooms.

Section F is devoted to academic laboratories. Separate chapters are devoted to those primarily for universities and colleges, the small college and for chemical engineering. Laboratory planning for specialized courses include sections on general chemistry, organic chemistry, analytical chemistry, instrumental analysis, inorganic synthesis, and physical chemistry, as well as a section on the chemistry lecture room.

Section G provides short descriptions well illustrated with photographs and floor plans of nine industrial research centers, five specialized research laboratories, three university buildings, and three general purpose college science laboratories.

This book concludes with an appendix which contains a list of construction during the period 1951–61 of laboratory facilities; a bibliography provides references for a more detailed study of specific problems connected with planning and construction of laboratory facilities; and a complete index.

Profusely illustrated with excellent photographs, clear line drawings, and floor plans, this volume is a pleasure to read. It is printed on good paper in easily-read type and well bound. Thorough planning, which is a central theme of the work, has been well done in the design, organization, and composition of this book.

This excellent volume should be carefully read and be in the constant possession of anyone responsible for the planning and construction of laboratory facilities for chemistry or chemical engineering.

F. B. Dutton
Michigan State University
East Lansing

Qualitative Anion-Cation Analysis: An Interpretative Laboratory Text of Semimicro Procedure in Basic College Chemistry

Emil J. Margolis, City College of New York. John Wiley and Sons, Inc., New York, 1962. x + 300 pp. Figs. and tables. 16.5 × 24.5 cm. $5.

This book is actually a laboratory text. The left-hand pages are white and contain the descriptive chemistry or "reference" reading. The right-hand pages are mustard-colored and give the "working directions." These pages are integrated so that the "reference" page gives the chemistry of the ion and the "working directions" on the opposite page describe how to perform the testing.

The usual twenty-four common cations are treated first in 164 pages. Thioacetamide is the source of the sulfide ion. The 21 anions are then discussed in 78 pages. The anions are divided into four groups, namely, the volatile group using dilute sulfuric acid, the barium and calcium nitrate group in slightly ammoniacal solution, the silver nitrate group in dilute nitric acid, and the soluble group. The anion scheme is devised primarily for only one anion in each group.

The appendix contains a non-tabular compendium of the color and solubility of simple salts listed under their anions. The bulk of the appendix contains about twenty pages of a glossary of laboratory devices, techniques and terms which are very adequate. There are no tables of ionization, solubility, or instability constants or electrode potentials in the text. The index is not a subject index, but a section index referring to the individual cations and anions with brief subsections such as (*a*) separation from— (*b*) indication of presence, (*c*) confirmatory test, etc.

The subject of equilibrium is referred to only a few times in the cation "reference" reading. In this respect the author assumes that equilibrium will be sufficiently covered in the first year chemistry course. The "reference" reading contains adequate ionic equations for all the chemical reactions used. There are no direct questions asked any place in the book.

The text is well written and very complete for the usual introductory course in qualitative analysis. The "working directions" are very complete. In fact, at times, they seem to be somewhat repetitious. However, this is no doubt needed for the less gifted student. There are several aside or "academic" references that should be of especial interest to the student which are quite valuable and knowledgeable. The book is remarkably free of errors.

Bruce V. Weidner
Miami University
Oxford, Ohio

Introduction to Ligand Field Theory

Carl J. Ballhausen, University of Copenhagen, Denmark. McGraw-Hill Book Co., Inc., New York, 1962. ix + 298 pp. Figs. and tables. 16 × 23.5 cm. $11.75.

At last, here is the book for the student of inorganic chemistry who wishes to learn about the modern theory of transition metal ions. All that the student wishes to see, from atomic spectra through group theory, and on through crystal field theory and the molecular orbital formulation, is here. The book is a monograph but will be widely used as a textbook, for the author has soundly started at the beginning of the subject, and has carried on through to the end.

Professor Ballhausen has been one of the most important workers in this field in the last ten years. It was to be expected that his book would be concerned with calculations and indeed it is; he shows how to calculate all of the quantities which are of interest for a metal complex: the g factor, the MO mixing coefficients, band intensities, the crystalline field energy of a d_{z^2} orbital in a tetrahedral field, and so on. The result is a mathematical book, and a most useful one. Many important formulas are derived, and a great deal of valuable information (transformation schemes, matrix elements, etc.) is included in tabular form. Lest the reviewer scare away the uninitiated, the theoretical discussion is always tempered by the experimental results, which are quoted freely. Let it be made clear that every transition metal chemist should have this book at his fingertips.

The *pièce de résistance* of this text is the last chapter, entitled Electronic Structures of Selected Inorganic Complexes. This chapter (23% of the book) surveys the descriptive chemistry of the *nd* transition metal ions in all of their important valence states. This survey details the type of compound (and stereochemistry) formed by each of these ions, and a discussion of the electronic structure in terms of spectra, magnetism, and energy level diagrams. The listing of 435 references for this chapter alone shows the extensiveness of this survey.

One invites comparison of this book with that of Griffith on the same topic. There is little similarity between the two, for Griffith's book is concerned with the sophisticated approach to the theory, and Ballhausen's book is more concerned with the applications of the theory. Ballhausen's introduction to atomic spectra and group theory, however, are too brief for the untutored.

The index also serves as a formula index. A name index is not included.

R. L. Carlin
Brown University
Providence, Rhode Island

Encyclopaedic Dictionary of Physics. Volume 7, Stellar Magnitude to Zwitter Ion

J. Thewlis, editor-in-chief, Atomic Energy Research Establishment, Harwell, England. Macmillan Co., New York, 1962. ix × 866 pp. Figs. and tables. 19.5 × 25.5 cm. $298 per eight-volume set.

With the arrival of Volume 7 of the Encyclopaedic Dictionary this work is completed except for the index. The topics in this volume range from Stellar Magnitude to Zwitter Ion in 866 pages. Among the topics included herein are Temperature with 30 pages, Thermodynamics with 35 and X-rays with 63.

On the historical side of thermometry one finds: "The common liquid-in-glass thermometer is one of a small group of instruments in use today which have their origins contemporary with the earliest stirrings of modern scientific thought (some others: telescope, barometer). The invention of the thermometer is attributed to Galileo. . . . A Swedish astronomer, Anders Celsius, suggested a 100 degree scale in 1742 in which the freezing point of water is taken as 100° with the scale descending to zero, the boiling point of water. This was supposed to obviate the necessity for negative numbers below the freezing point of water. The centrigrade scale in its present day form seems to have been devised by Christin of Lyons in 1743, although it is commonly attributed to Celsius. Thus, by pure coincidence, the symbol "°C" may be interpreted as "degrees centrigrade,"

(*Continued on page A528*)

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Edited by HANS B. JONASSEN, *Professor of Chemistry and Chairman of the Department, Tulane University; and* ARNOLD WEISSBERGER, *Research Laboratories, Eastman Kodak Company, Rochester.*

This new series is a comprehensive presentation of the various techniques used in inorganic and radiochemistry, and serves as a supplement to *Technique of Organic Chemistry*, edited by Arnold Weissberger. In addition to treating topics not covered in the older series, *Technique of Inorganic Chemistry* extends organic techniques into the realm of inorganic chemistry.

Each chapter in this series offers a theoretical treatment of specific techniques and critically evaluates their limitations and merits. Although some chapters lean heavily on material in *Technique of Organic Chemistry*, this material is reformulated from the viewpoint of the inorganic chemist. In all cases, the authors stress recent developments. An Interscience book. Volume I: *1963. Approx. 280 pages. Prob. $11.50.* Volume II: NUCLEAR CHEMISTRY (*by* NOAH R. JOHNSON, EUGENE EICHLER, and G. DAVIS O'KELLEY, *all of the Oak Ridge National Laboratory*): *1963. Approx. 212 pages. $8.50.* Volume III: *1963. Approx. 320 pages. Prob. $12.50.*

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By H. VAN OLPHEN, *Shell Oil Company.* Applies the general facts and current theories of colloid chemistry to specific clay systems, stressing the effect of changes in fluid composition on the forces acting between suspended clay particles, and on the bulk physical and mechanical properties of important clay suspensions. An Interscience book. *1963. Approx. 296 pages. Prob. $12.00.*

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By ROALD K. WANGSNESS, *University of Arizona.* Provides a solid background in classical mechanics and electromagnetism, penetrating deeply into the field without the use of complicated mathematics. *1963. 413 pages. $9.75.*

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Edited by CHARLES G. OVERBERGER, *Polytechnic Institute of Brooklyn.* This series provides detailed directions for the synthesis and characterization of macromolecules, including those of biochemical origin. Volume I: *1963. Approx. 96 pages. Prob. $4.75.*

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PHYSICS AND CHEMISTRY OF THE ORGANIC SOLID STATE Volume I

Edited by D. FOX, *State University of New York at Stony Brook;* MORTIMER M. LABES, *the Franklin Institute; and* ARNOLD WEISSBERGER, *Eastman Kodak Company.* An Interscience book. *1963. Approx. 860 pages. Prob. $31.00.*

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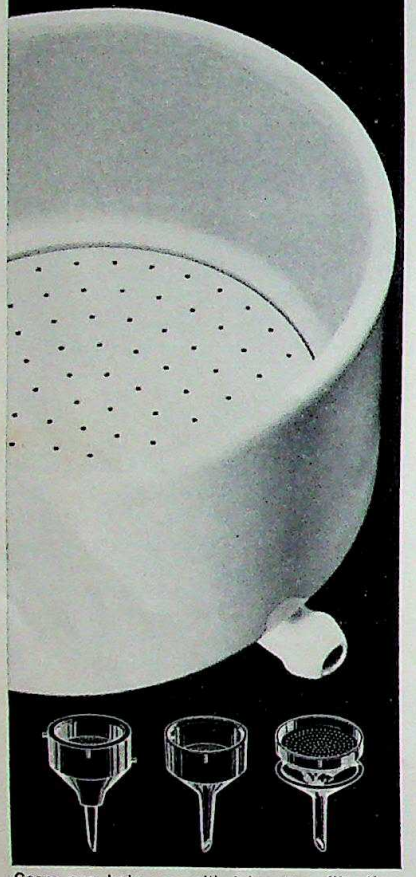

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BOOK REVIEWS

"degrees Celsius," or even "degrees Christin," with justification."

Following the long article on different aspects of temperature there come a few short articles on temper (physical) and then a mathematical one on the tensor. For this latter article of two pages, it is not unfair to say that if one knew nothing of tensors before reading the article one would know little more after reading it. What value such articles are supposed to have is difficult to say for there is not nearly enough for the uninitiated while the person who is familiar with the material will not need it or can go to a more complete discussion in one of the recommended books. There is little question that the concept of a tensor could be given in a meaningful manner such that the physics of the problem could be appreciated and the mathematical clothing be added later. Fortunately not all mathematical articles are written in this manner.

It is interesting to note that in 1824 when Carnot published his famous paper on the "motive power of heat" he made use of the old "caloric" assumption to show that the "maximum theoretical efficiency of any heat engine operating between a given set of heat reservoirs is the same as that of a reversible engine so operating, and is a function only of the temperatures of the reservoirs . . . ." It was essentially for a proof of the above statement that the various formulations of the second law were given for the "second law of thermodynamics is any 'law,' 'proposition,' 'hypothesis,' etc., that may be used as an axiomatic point of departure for proving the truth of the *Carnot principle*." There is an interesting discussion on the third law of thermodynamics originally given by Nernst in 1906 in a paper entitled "On the calculation chemical equilibria from thermal measurements." This is continued with the work of Sir F. Simon who reformulated the third law.

The article on "Wave Mechanics" should be found both interesting and useful to many readers. Also the numerous articles on different aspects of X-rays are valuable and instructive.

This volume maintains the high standard of the previous volumes and the complete set should be of real value to almost every scientist. There is, of course, the obvious difficulty that such a work as this will date relatively quickly with the rapid advance of science. In this connection it is interesting to note that under the title of "Venus" it states "The period and axis of rotation are not known." However, despite the present rapid changes in science this dictionary will be of great use for many years.

R. J. Stephenson
Department of Physics
The College of Wooster
Wooster, Ohio

Note:

The "Encyclopaedic Dictionary of Physics," which has been reviewed in THIS JOURNAL, 39, A426 (May, 1962), and 40, 105 (January, 1963), is now being published and distributed by the Macmillan Company rather than the Pergamon Press. The price of the entire set is $298. but the Glossary may be purchased separately at $60. The price noted earlier was a pre-publication offer. Any correspondence regarding this set should be addressed to The Macmillan Co., 60 Fifth Avenue, New York 11, N. Y.

Molecular Genetics, Part 1

Edited by *J. Herbert Taylor*, Columbia University. Academic Press, Inc., New York, 1963. xii + 544 pp. Figs. and tables. 15.5 × 23.5 cm. $14.50

This book is the first of a two or three volume series designed to provide a thorough discussion of the field of research which is concerned with the nature of the molecular interactions involved in the mechanisms of heredity. Reviews of specialized, circumscribed areas of this field have appeared in numbers, but to my knowledge this is the first attempt to put together at an advanced level a complete picture of the entire field of molecular genetics.

The workers in this field are derived from a variety of scientific disciplines and tend to form rather widely diverse groups, each concerned primarily with one particular aspect—the enzymatic steps of protein synthesis, the physical chemistry of the nucleic acids, the structure of chromosomes, the events of virus replication or a number of others. It is very difficult for one such group to keep abreast of the developments and the thinking of the others, although commonly they may be approaching the same fundamental research goal by different avenues.

"Molecular Genetics" should provide valuable assistance in remedying this situation, at least until the time, hopefully not too distant, at which further advances have outdated major portions. Any worker in the field who wishes to be brought up to date concerning the activities of his colleagues in related areas would be bound to profit greatly from the reading of this book. In addition, many teachers of advanced courses in genetics, molecular biology, nucleic acids or the like, as well as their students, will also find much material of value in broadening their outlook upon these areas.

Perhaps the best appraisal of the scope of the material and of the caliber of the authors can be gained simply by a quick glance at the table of contents. In order, the various chapters are: The Replication of DNA in Cell-free Systems, by M. J. Bessman; The Replication and Organization of DNA in Chromosomes, by J. H. Taylor; The Organization of DNA in Bacteriophage and Bacteria, by C. A. Thomas, Jr.; Cellular control of DNA Biosynthesis, by K. G. Lark; Molecular Mechanism of Mutations, by E. Freese; Biosynthesis of RNA in Relation to Genetic Coding Problems, by E. Volkin; Kinetic Studies of the Synthesis of RNA and Ribosomes, by R. B. Roberts, R. J. Britten, and B. J. McCarthy; Protein Synthesis in Relation to Gene Action, by R. Schweet and J. Bishop; Correlations between Genetics and Chemistry of Human Hemoglobins, by C. Baglioni; and Contributions from TMV Studies to the Problem of Genetic Information

(*Continued on page A530*)

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RECENT McGRAW-HILL TEXTS

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An authoritative account of the basic principles of Mass Spectrometry, together with the more important types of applications. Because Mass Spectrometry covers a wide range of research interests in many branches of science, and because the scientific techniques used in the construction and applications of modern mass spectrometers are specialized and intricate, each area is described by an expert.

INTRODUCTION TO WAVE MECHANICS

By LOUIS HARRIS and ARTHUR L. LOEB, both of the Massachusetts Institute of Technology. 300 pages, $8.95.

A self-contained textbook for a one-semester course, presenting most of the principles of non-relativistic wave mechanics, and examples illustrating applications of these principles. The authors provide a logical sequence of topics, each discussed in detail. Important principles are illustrated by examples, and reinforced through problems interspersed throughout the text. Emphasis is on depth and detail, rather than on breadth of coverage.

ENTROPY

By J. D. FAST, Chief Metallurgist Philip Research Laboratories and Professor at the Technical University of Eindoven. 313 pages, $10.75.

This book has been prepared in order to develop and elucidate the significance of the concept and its applications in science and technology in a manner clear enough to be readily understood by physicists, chemists, and students. The author presents basic, necessary principles of thermodynamics, statistical mechanics and quantum mechanics in such a manner that the nontheoretician can profit from an understanding of the valuable entropy concept. This treatment of entropy was so successful in an earlier Dutch edition that the present volume is being simultaneously published in Dutch, English, French, German, Spanish and Polish.

PHYSICAL AND CHEMICAL METHODS OF SEPARATION

By EUGENE W. BERG, Louisiana State University, Baton Rouge. 366 pages, $12.50.

This text presents eighteen laboratory separation techniques. The author's aim is to enable the advanced student to recognize the inherent limitations of these separation methods and the type of system to which each method would be applicable. Emphasis is on the physical principles which govern the behavior of a given method. An effort is made to pin-point the important system variables with a minimum of mathematical detail. Experimental detail is avoided through the use of schematic diagrams of the needed equipment, with brief descriptions of the technique.

CHEMICAL THERMODYNAMICS

By J. G. KIRKWOOD and IRWIN OPPENHEIM, latter of the Massachusetts Institute of Technology. McGRAW-HILL Series in Advanced Chemistry. 261 pages, $8.75.

A senior or graduate level text requiring physical chemistry as a prerequisite, it contains a new formulation of the Second Law and an important statement of the relationship between the Second Law and Caratheodory's principle. The authors have prepared a rigorous and closely reasoned discussion of thermodynamic fundamentals, developing coherently the application of these principles to systems of interest to chemists.

INTRODUCTION TO CHEMICAL INSTRUMENTATION

By EDWARD J. BAIR, Indiana University. McGraw-Hill Series in Advanced Chemistry. 349 pages, $10.75.

An introduction, for the experimental chemist, to a detailed understanding of the design and operation of chemical instruments. Emphasis is on the flow of signals and the information they represent. Designed for graduate students and research workers, the book covers a representative collection of topics which should give the student an insight into new advances in instrumentation as they appear in chemical literature, and an insight into the art of designing instruments for new applications.

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Naturally there is some variation from chapter to chapter in the treatment of the material, but in general each author has adhered remarkably well to the stated aim of providing a readable, very current account of the major streams of research in his own area of specialization. The various chapters are not necessarily comprehensive reviews of the literature; rather they include that material most well known to the author and deemed by him to be most significant with respect to future progress. This does lead to some duplication on one hand and to the omission of a number of important aspects on the other. Presumably the major omissions at least will be rectified by discussions in Part 2 of the series. I am looking foward to its appearance.

JAMES L. FAIRLEY
Michigan State University
East Lansing

Science for the Non-Scientist

A. R. Patton, Colorado State University, Fort Collins. Burgess Publishing Co., Minneapolis, Minnesota, 1962. v + 125 pp. Figs. and tables. 14 × 21.5 cm. Paperbound. $2.50.

This is a short (115 pages) paperbound volume written to be used in a course with about "50 lecture and discussion periods" for "students who will not become scientists, technologists, or engineers, but need to know something of what science is about in order to become intelligent citizens in an age of science."

The author attempts to define science and to describe the scientist in practical terms. He then discusses the following topics: space, time, atomic structure, bonding, equilibrium, colloids, and the first and second law of thermodynamics—all without the aid of mathematics. The impossibility of such a task in the time alloted is overshadowed only by the need.

A novel and interesting approach is used. Principles are illustrated with examples from the area of biochemistry. Interesting facts and bits of information, such as the origin of names, are woven into the descriptive matter. Most people in scientific areas would find it good reading.

Needless to say, one large volume could not adequately cover the topics discussed, even with mathematics. Were one to use this text, he would need supplemental material (even for the 50 study periods).

The selection of topics, the general approach and the atmosphere of the volume merit the investigation of those who would attempt to give an understanding of science to otherwise educated people.

GARTH L. LEE
Utah State University
Logan, Utah

Editor's Note: The following comment is taken from the report of a student who used this book as supplementary reading in a science course for humanities majors. "... The very size of the book defies the pretentious title. A student majoring in the humanities will not become automatically "two-cultured" by reading it. However, Patton's discussion of scientific attitudes is so direct and well documented by clear examples that no person previously mystified or overawed by science can miss the point."

Inorganic Syntheses. Volume 7

Jacob Kleinberg, editor-in-chief, University of Kansas, Lawrence. McGraw-Hill Book Co., Inc., New York, 1963. xi + 335 pp. Figs. and tables. 15.5 × 23.5 cm. $8.95.

In its latest volume, this series continues to present "tested methods for the preparation in high purity of inorganic compounds of potential value to the research chemist." For the first time, in addition to its function in research, the work is acknowledged to provide "a source of compounds and techniques for senior or graduate courses." Among the numerous techniques and reactions which will constitute a challenge to students are inert or anhydrous atmospheres, high temperature and sealed tube reactions, electrolytic and vapor phase reductions, nonaqueous solvents, isotopic syntheses, and high vacuum methods. The types of preparations include both simple, complex, and polymeric compounds of a wide variety of elements, with emphasis on periodic groups VA and VIII.

Extensive articles are devoted to volatile hydrides of groups IVA and VA, cyclopentadienyl metal carbonyls and derivatives, anhydrous metal chlorides, unipositive halogen complexes, and inner complexes of cobalt(III) with diethylenetriamine. Coordination compounds, especially isomers of the platinum metals, are heavily represented.

The general organization of *Inorganic Syntheses* has been described in a review of the previous volume (J. CHEM. EDUC., **38**, A552 [1961]). In Volume 7, 65 entries, 14 by foreign contributors, give detailed procedures for the preparation of more than 110 compounds. The index of contributors has, for the first time, been

(*Continued on page A532*)

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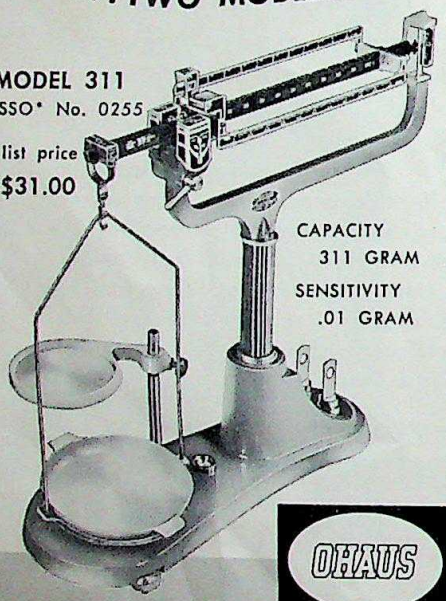

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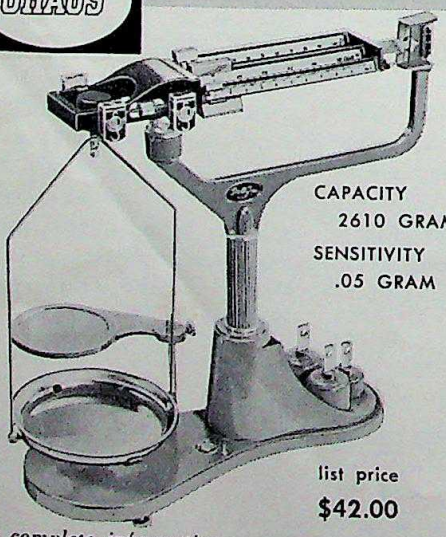

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By **E. Calvet,** *Institute of Microcalorimetry and Thermogenesis, Marseilles, and* **H. Prat,** *Faculty of Sciences, Marseilles, and the University of Montreal*

Newly translated from the French, this valuable study introduces a new research tool—the Tian-Calvet Microcalorometer. This instrument provides a self-recording measure of minute heat outputs over periods of days, or even months. The first part of the book expounds the theory and practice of the microcalorimeter, and the second describes some of its physico-chemical applications. The third part deals with thermal studies on seed-germination, the growth of bacteria, and the effects of antibiotics on insect metamorphoses and on the thermogenesis of reptiles and new-born mice.

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BIOSYNTHESIS OF LIPIDS

Volume VII of the Proceedings of the Fifth International Congress of Biochemistry in Moscow

Edited by **G. J. Popjak,** *Experimental Radiopathology Research Unit, Hammersmith Hospital, London*

The reports of specialists from five different countries are included in this survey of the latest research developments in the biosynthesis of fats. The papers include new information on the biosynthesis of branched chain and odd-numbered fatty acids, of bacterial branched chain acids, and of ubiquinone. Among the contributors are A. Teitz (Israel); E. Lederer (France); R. R. Dils, G. J. Popjak, and J. Glover (England); and L. T. Samuels, S. Goodman, and M. Tomkins (U.S.A.).

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Approximately 425 pages, $18.00

DICTIONARY OF CHEMISTRY AND CHEMICAL TECHNOLOGY (ENGLISH/GERMAN/POLISH/RUSSIAN)

English Editors: **Professor H. Stephen** *and* **Dr. T. Stephen,** *Oxford*

In 724 pages, this dictionary lists some 12,000 English terms arranged in alphabetical order. Equivalent terms in each of the other three languages are shown alongside and numbered consecutively. Immediately following the main text is an index of English synonyms for chemical compounds, to which reference can be made if a term cannot be found in the principal listings. German, Polish, and Russian alphabetical indexes conclude the dictionary.

A Pergamon Press Book *724 pages, $30.00*

SOLUBILITIES OF INORGANIC AND ORGANIC COMPOUNDS, Volume I (in two parts) Part I, Binary Systems

Edited by **Professor H. Stephen** *and* **Dr. T. Stephen,** *Oxford*

The material comprising the contents of this work was obtained from a detailed survey of periodical literature in all languages conducted by a panel of scientists appointed for the purpose by the Academy of Sciences of the U.S.S.R. It is a comprehensive survey of data published on the solubility of elements, inorganic compounds, metallo-organic and organic compounds in binary, ternary, and multicomponent systems. Volume I deals with solubility in water and anhydrous solvents. Information is presented in the form of 6,540 tables, arranged systematically for easy reference. Table 1 lists the solubility of about 2,000 compounds in water; each subsequent table is devoted to the solubilities of a single compound or a group of related compounds.

A Pergamon Press Book *1964 pages. $28.50*

International Series of Monographs on Analytical Chemistry Volume 8

ORGANIC FUNCTIONAL GROUP ANALYSIS

By **F. E. Critchfield,** *Union Carbide Chemicals Company, West Virginia*

This book provides analytical chemists with a collection of versatile and reliable chemical methods for determining most of the more common organic functional groups. The scope and known limitations of each method are discussed so that the reader can decide which of the methods under consideration can best be applied to his particular problem. Some of the analytical methods, developed and used in the author's laboratories, have never before appeared in print. All procedures are described in terms readily comprehensible to trained technicians not holding university degrees.

A Pergamon Press Book *195 pages, $6.50*

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made cumulative for all the volumes. Since any compound consists of two or more elements, the cross-references which now appear at the beginning of each chapter are another new and helpful feature. Systematic nomenclature is strictly adhered to, and largely because of the influence and authority of this series, names such as sodium hydrogen carbonate ($NaHCO_3$) and lithium tetrahydroaluminate ($LiAlH_4$) may in time lose much of their strangeness.

In view of the accelerated pace of inorganic research in recent years, it is hoped that this excellent series will appear at more frequent intervals. Dr. Kleinberg and his editorial board are to be congratulated for producing a scholarly, accurate, and extremely valuable volume that maintains the high standards set by its predecessors.

George B. Kauffman
Fresno State College
Fresno, California

Advances in Petroleum Chemistry and Refining. Volume 6

Edited by *John J. McKetta, Jr.*, University of Texas, Austin. xvi + 550 pp. Figs. and tables. 16 × 23.5 cm. $21.

Like other volumes of this series this one is a potpourri of technical subjects. Two are of general interest to chemical engineers: membrane permeation and clathration; and a chapter on centrifugal compressors should be of general interest to mechanical engineers. A chapter on carbon-silicon compounds should appeal to chemists, and four others—on octane ratings, pyrolysis operations, grease technology, and sulfur production from natural gases—should be of interest to petroleum technologists.

The chapters on membrane permeation and clathration are general discussions of these two new separation processes. They should be useful references for new workers in these fields, and they may also be of interest to established workers, who will find a compilation of references in each field.

The chapter on centrifugal compressors appears to be a thorough discussion of the subject, and should be helpful to any interested engineer who is not well acquainted with the principles involved in their design and operation. Surprisingly, no references are cited; consequently, this chapter will probably not be of much use to those who are active in the field.

The chapter on carbon-silicon compounds is a survey of methods for manufacturing these interesting chemicals, whose use has grown rapidly. Forty-nine references are cited.

The chapter on octane ratings describes research, motor, and road ratings and their interrelationships, discusses their accuracy, and considers the problems of calculating the ratings of blends. It should be of use to those who use octane ratings but who have not had much experience in developing basic octane data.

The chapter on pyrolysis appears to fill a void in petroleum technology; as the authors indicate, heretofore there have been few quantitative pyrolysis data (or correlations) in the literature. To fill this void, the authors present correlations for thermal cracking, for visbreaking, and for thermal reforming of various feed stocks, together with samples of how to use them. The correlations, which are based on "published and unpublished data," include no data points, presumably because the data had to be adjusted to common conditions before they could be correlated.

The chapter on greases summarizes grease developments in the last two decades, during which the technology has changed greatly. The various greases developed in this period are described, methods of manufacture are discussed briefly, and testing procedures are outlined.

The chapter on sulfur recovery from natural gases surveys the extensive literature on the subject (632 references are cited) and discusses the operations of two commercial plants, one "old" and one modern. This chapter should be of interest to anyone who is concerned with the design or operation of sulfur recovery plants.

As with most books of this type, no general recommendation can be made

(*Continued on page A533*)

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concerning this volume. It probably should be included in university libraries where petroleum engineering is offered. For other cases, the librarian should decide on the basis of the possible utility of the several chapters.

R. J. Hengstebeck
American Oil Company
Whiting, Indiana

Historical Roots of the Principle of the Conservation of Energy

Erwin N. Hiebert. The State Historical Society of Wisconsin, Madison, 1962. 118 pp. Figures. 15.5 × 23 cm. $3.50.

The history of the development of a theory or principle is often of equal or greater interest and importance than the biography of an eminent scientist or the story of the discovery and progressive application of a widely used material. In general, however, it is more difficult to produce a competent and accurate account in the former case since the author must not only be familiar with the writings that bear on topic but he must also be able to extract the essence of these writings and link them with what went before and what came after. The monograph under review here is devoted essentially to tracing the historical roots of the principle of conservation of energy within the framework of the science of mechanics proper.

After an introduction, the author presents his work in three chapters: Concept of Virtual Work; Quantity of Motion; Latent Forces of Inelastic Collision. The final chapter (Conclusions) opens with the statement: "Thermodynamics owes its origin to the fertile synthesis of mechanics and heat theory which took place in the middle of the nineteenth century. A comprehensive understanding of the historical circumstances leading to the synthesis necessarily presupposes considerable familiarity with the status of heat theory and mechanics antecedent to the emergence of thermodynamics as a separate discipline. This study explores certain aspects of the history of mechanics which were essential to the establishment of thermodynamics in the nineteenth century."

The treatment is nonmathematical; there are 15 simple but pertinent diagrams. The book reads smoothly and the translated excerpts are well done. The bibliography is divided into "primary" sources (43 entries) and "secondary" sources (45 entries) in a number of languages. The index is adequate.

Obviously this historical monograph will appeal mostly to teachers and graduate students of physics; it offers little that will interest the great majority of chemists. It is recommended to physical chemists, particularly those concerned with thermodynamics and the history of its elements.

Ralph E. Oesper
University of Cincinnati
Cincinnati, Ohio

Rogers' Inorganic Pharmaceutical Chemistry

Taito O. Soine, University of Minnesota, Minneapolis, and *Charles O. Wilson,* Oregon State University, Corvallis. 7th ed. Lea and Febiger Publishers, Philadelphia, 1961. 704 pp. Tables. 16 × 24 cm. $10.

This new edition, which conforms to standards of the USP XVI and the N.F. XI, maintains the high standards set by the authors in the previous editions. The publishers have gotten away from the glossy paper thereby making the text easier to read by artificial light. Much of the descriptive material which was found in the earlier editions, i.e., that had been taken from the USP and the N.F., has been deleted in this edition. In addition, the first chapter has been rewritten to include information on atomic structure and the nature of the chemical bond. The chapter on solubility has been expanded greatly in keeping with more recent information on this subject, permitting the student to understand more theory and therefore to be able to make wise predictions concerning the solubility of drug constituents in the various dosage forms. The discussion on radioactivity has also been expanded.

Throughout the text the material has been presented on a much higher level, which is in keeping with the requirements in the expanded pharmaceutical curriculum. This volume contains a wealth of information on inorganic chemicals

(*Continued on page A534*)

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which are used as drugs such as commercial methods of preparation, physical and chemical properties, standards and tests for identity and purity, as well as a discussion of their use and dose in medicine.

The text is necessary in the pharmacy curriculum and serves well as a reference book in chemical laboratories.

N. M. Ferguson
University of Houston
Houston, Texas

Salt Water Purification

K. S. Spiegler, Technion-Israel Institute of Technology, Haifa, Israel. John Wiley and Sons, Inc., New York, 1962. ix + 167 pp. Figs. and tables. 15.5 × 23.5 cm. $7.50.

In these days of government-sponsored programs in fields such as the improvement of saline water we have come to accept the idea of research by committee. Certainly it is becoming more and more common to have books written by committees, and the result in some cases is what one reviewer has called the "non-book." It is refreshing occasionally, therefore, to come across a book such as this informative little volume written by one man, which tells us more about salt water purification than many of the annual reports issuing from various offices in Washington.

Newcomers to the field of water desalting, and any others who want an overall view of the present state of this rapidly expanding field, will welcome this review. There is a detailed discussion of various distillation processes carried out at a fairly elementary level with lucid diagrams as an aid. It is interesting to learn that in order to use a solar evaporator to provide irrigation water we would need 1 unit area of evaporator pan for every 3 units of irrigated land area.

Electrodialysis equipment is compared in terms of a power index:

$$\frac{\text{Electric power per unit of fresh water produced}}{\text{Production rate per unit area of membrane}}$$

In terms of this index we can see that small household units are not very efficient in terms of power consumption when compared to the large scale plants. We learn also that such cells should be operated at an optimum current density, i:

$$i = \left(\frac{b}{a}\right)^{1/2}$$

The term a is proportional to the cost of power, whereas b is proportional to the cost of plant. It is in giving such details as this that the book is most valuable.

The minimum energy requirements for sea water purification are discussed in a simple manner also. Imagine an apparatus consisting of two reservoirs, one containing salt water, the other fresh water, both partly filled with liquid and evacuated. The two containers are connected at the top through a compressor. Since the vapor pressure of fresh water is higher than that of salt water, the fresh water would eventually distill over into the salt water container. However, if we use the pump we could push the water vapor the other way from the salt water container into the fresh water container. The work done by a hypothetical pump of this kind working against a vapor pressure difference of 1.84% between sea water and fresh water (equilibrium vapor pressure of pure water is 0.0312 atm. at 25°C) is 0.0312 atm. × 1.84 × 43.4 liters per gram of water vapor = 0.0249 liter atm. per gram of water = 0.70 kwhr./m³ = 2.65 kwhr/1000 gal.

The chapter on scale is a useful one also, particularly to teachers of freshman chemistry courses who might want to bring up to date their discussion of hardness in water. Chemistry teachers will find the whole book useful as a source of interesting examples of modern applied chemistry.

Dr. Spiegler brings us back to reality in his summary when he states that unless sensational breakthroughs are made in water desalting, it will be more economical to transport agricultural products to arid regions than to grow them there by irrigation with converted sea water.

J. A. Schufle
New Mexico Institute of Mining and Technology
Socorro

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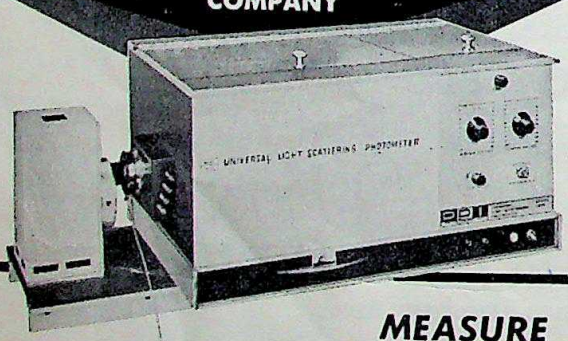

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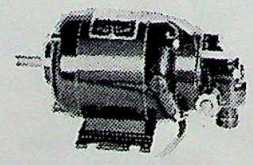

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Submitted by: Professor J. M. Saurer, 41 Rue P.-Jolissaint, St. Immier, Switzerland.
Checked by: Roger Wheaton, Michigan State University, East Lansing, Michigan

PREPARATION

Provide sticks of soft white chalk (the hard-pressed chalk found in many American classrooms will not work. Number 320 white chalk made by Binney and Smith, Inc. and sold at S. S. Kresge Co. Stores is suitable), 0.1 *M* solutions of $Cd(NO_3)_2$ and $Pb(NO_3)$, a source of H_2S, a beaker, and three test tubes.

DEMONSTRATION

Show the color of cadmium sulfide by adding H_2S to cadmium nitrate in a test tube. Show similarly the color of lead sulfide, and the color of the mixed sulfides formed by adding H_2S to a 1:1 mixture of the two salts.

Place some of the mixture in the bottom of the beaker; stand a piece of white chalk on end in the solution. After 15–20 min, expose the chalk to H_2S, and observe at the bottom of the piece of chalk a dark brown zone and above that a long yellow zone.

SOLVAY PROCESSES

A Chem Ed TESTED DEMONSTRATION

Submitted by: Robert J. Johns, Academy of the New Church College, Bryn Athyn, Pennsylvania.
Checked by: Roger Wheaton, Michigan State University, East Lansing, Michigan.

PREPARATION

Provide a large balloon filled with c
ml concentrated ammonia solution sa
a bottle, a one-hole stopper, and a
nected to the balloon.

DEMONSTRATION

Flush the air out of the top of the
bon dioxide. Attach the balloon to
rubber tube, as shown in *A*, and sha
serve the solution of carbon dioxi
(20–30 minutes) the formation o
$NaHCO_3$. Depending on its size, it
to refill the balloon.

REMARKS

An alternate procedure makes u
source of carbon dioxide, as desc
Gantz, E. St. C., and Rice, C. N.,

Laboratory Manual," Houghton-Mifflin Co., Boston

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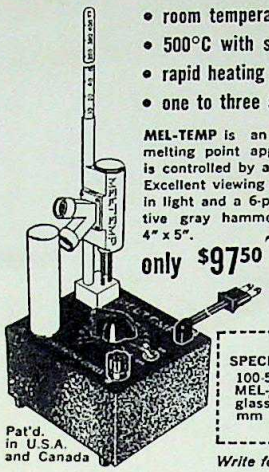

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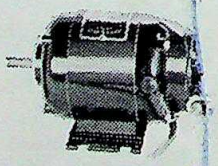

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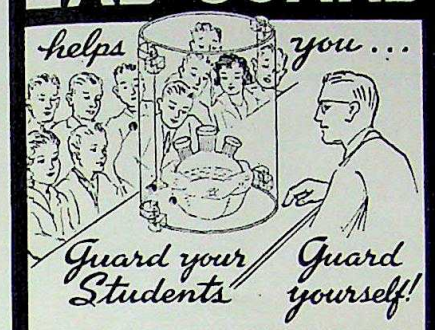

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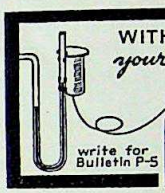

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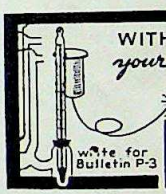

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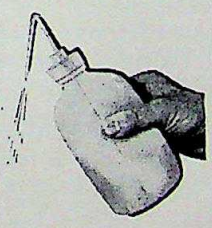

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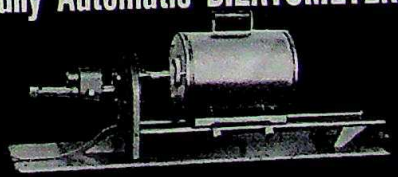

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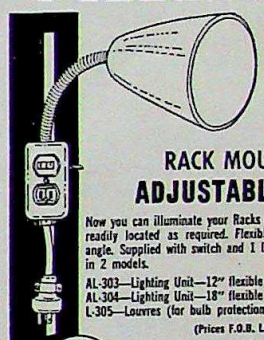

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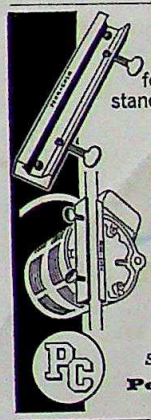

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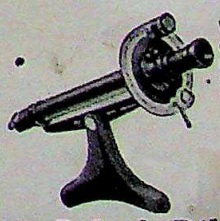

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See CARTAN, F., AND ANACKER, E. W., *J. Chem. Educ.*, **37**, 36 (1960).

One of the most precise methods for the determination of the densities of liquids makes use of a magnetically-controlled float. A glass float containing a small magnet or a piece of soft iron is completely immersed in the liquid and a current is passed through a solenoid until the float remains stationary in the liquid. It can be shown that the current required is a linear function of the density of the liquid.

The article describes a simple flotation apparatus that could be constructed by students. The theory is described in sufficient detail and the calibration of the instrument alone should be an interesting and instructive exercise. The authors describe several applications of the apparatus to both physico-chemical measurements and to chemical analysis. Accordingly, a well-constructed densimeter could be used by a number of students to study a variety of interesting problems.

Questions:

Construct flotation apparatus as described, calibrate it, and verify its accuracy and precision by measuring densities of a series of liquids whose values are known.

Study the factors that affect the reproducibility (precision) of measurements with your apparatus. These may be identified from the theory of the method, and verified experimentally. Make modifications as possible to improve the equipment.

Use the apparatus to monitor the purification of liquids by distillation, for example. What are the limitations of such a procedure?

Select an interesting application among those suggested by the authors and study a related problem with the apparatus.

"Densiometric" titrations are mentioned as a possible application. Compare the results obtained in this manner with those found by more conventional methods, with respect to precision and accuracy.

An interesting modification of the apparatus described to make possible rapid routine measurements of density is described by A. R. Richards in *Ind. Eng. Chem., Anal. Ed.*, 14, 595 (1942). Such an apparatus could be constructed for analysis of anti-freeze solutions, the results correlated with freezing point determinations, and compared with commercial hydrometers.

Float Method for the Analysis of Solutions

See OSBURN, J. O., AND CHOI, I. C., *J. Chem. Educ.*, **38**, 578–80 (1961).

No other technique readily available to the beginner is as precise as the use of a suspended float to determine the concentration of solute in a solution. With care and with apparatus which can be easily built, sensitivity of the order of 1×10^{-5} g of solute /ml of solution can be attained. A hollow cylinder of glass, about the size of a grain of wheat, or smaller, is constructed from glass tubing and closed at both ends. By trial and error, adding or removing bits of glass with the aid of a tiny blow torch constructed of small bore glass tubing, tiny floats are fashioned which have the desired density—using liquids of approximately the right density to test the float from time to time as it is fashioned.

The float is calibrated by immersing it in solutions of known concentration, and determining the temperatures at which, for each solution, the float remains suspended within the liquid. Then, within the range of temperatures provided by the calibration, quite precise determinations of solute concentration can be quickly established.

A water bath in which temperature can be controlled to about ±0.005°C is also required. It can be constructed from a glass-walled fish aquarium (since the sides of the water bath must be transparent). A powerful stirrer is needed, as is a thermo-sensitive device constructed of glass tubing and filled with mercury (or with mercury and a liquid with a high coefficient of thermal expansion; see the cumulative indexes of J. CHEM. EDUC. for suggestions), coupled to a relay and electrical heater. For very precise temperature control, some investigators have found it desirable to continuously cool the water bath while it is intermittently warmed by the electrical heater.

Questions:

Use the float method for the analysis of solutions as a technique for answering one of the questions asked in another project in this series.

Equation (1) in the article is derived upon the assumption that the density of the glass float does not change with temperature. Is this a valid assumption? If not, can you derive a more rigorous equation, using data you have obtained which describe the change in density of one of your floats as a function of temperature?

The authors suggest that the temperature be directly determined at which the float remains motionless, suspended in the liquid whose density is of interest. Is this necessary? For example, can you measure the rate of fall of the float at one temperature, and its rate of rise at a slightly lower temperature and from these data determine the unique temperature at which the float would be stationary? If so, is this procedure more, or less, precise; is it easier, or more difficult to accomplish? Are there any other modifications in the recommended procedure which will increase the precision or ease of the experimental work?

When viscous solutions are centrifuged, for example, solutions containing a high concentration of sugar, it might be expected that the concentration of the solute would vary along the length of the centrifuge tube. Does this actually happen? If so, can you determine a relation between the magnitude of the phenomenon and the duration, or revolution rate, or both, of the centrifuging?

Can you detect any evidence for varying concentrations of deuterium oxide (heavy water) in water from different sources available to you? If so, do the variations in the amounts of the heavy isotope of hydrogen correspond to what you expected or do they contradict your expectations? Account for unexpected results if these are obtained, and test your explanation with further laboratory work.

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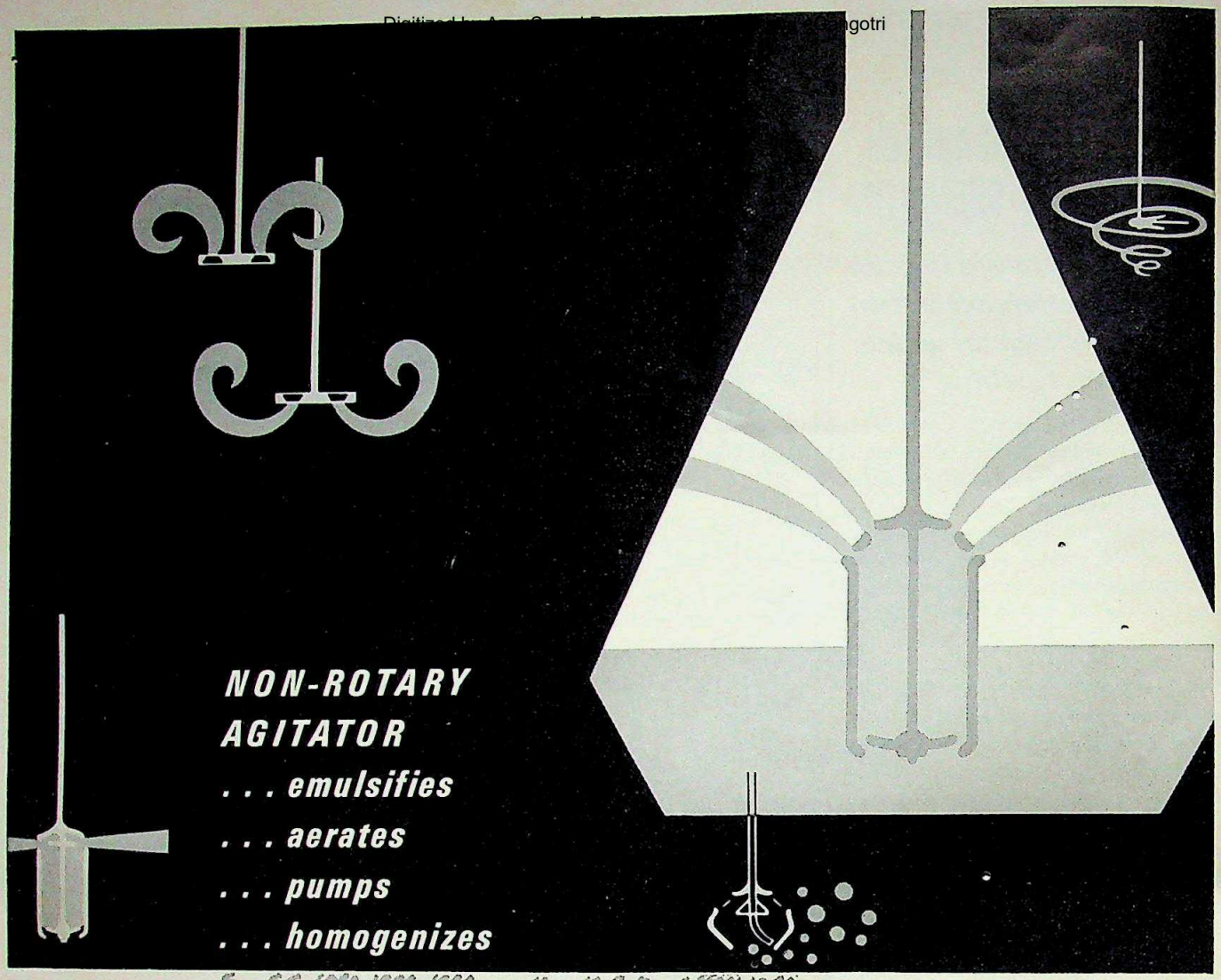

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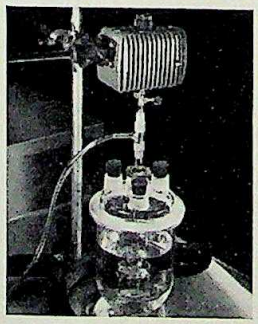

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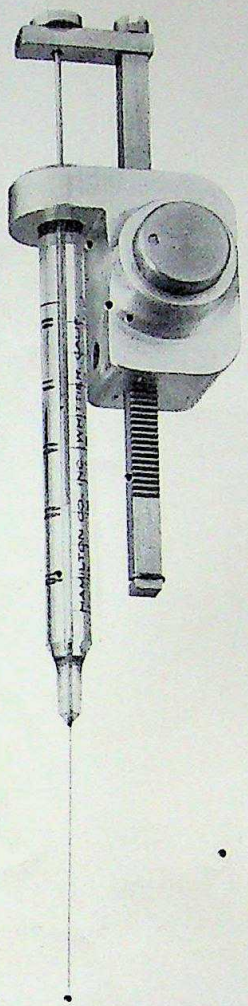

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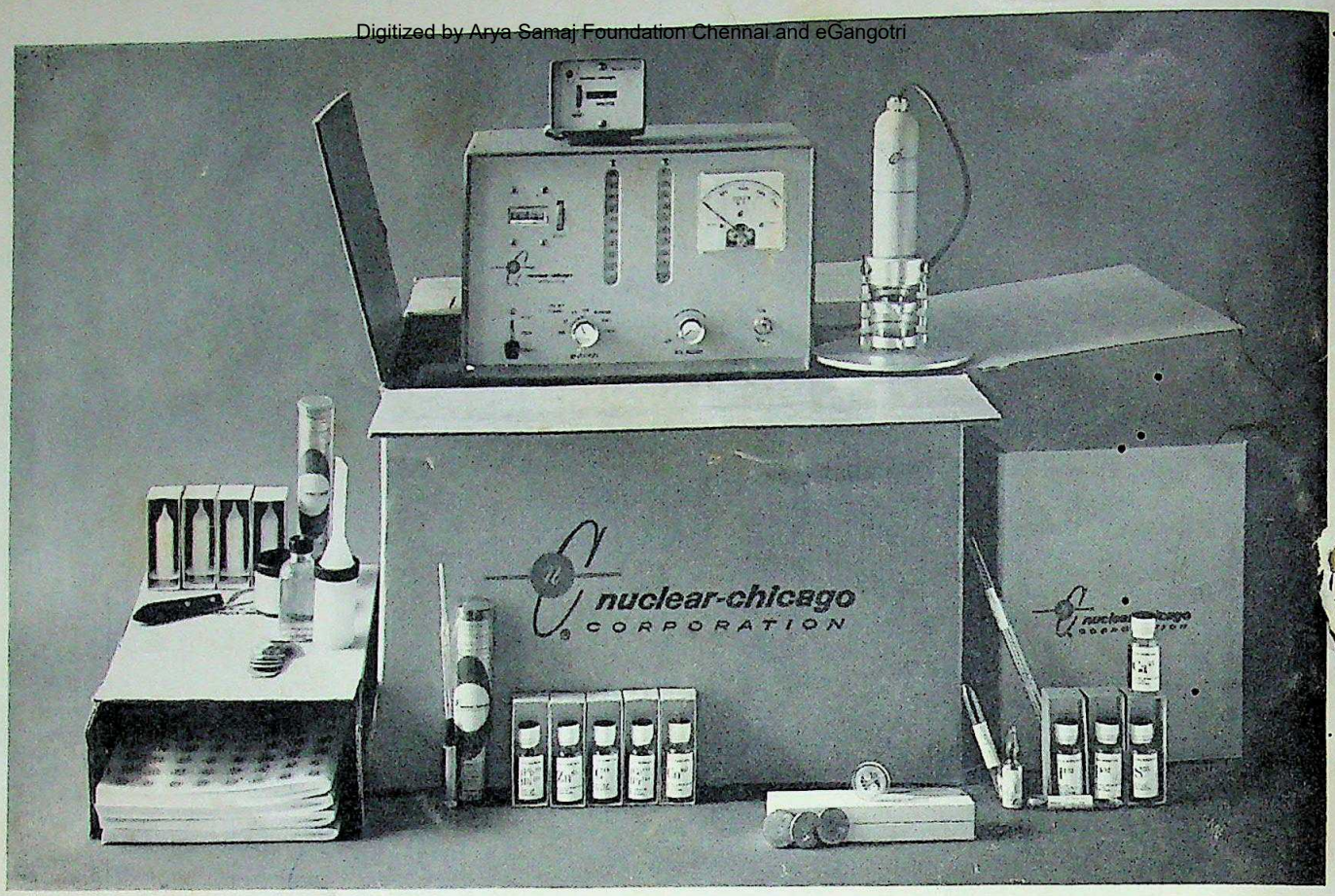

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Exchange Resins in The Qual Lab . . . page 416

Bromonium Ion . . . 392

MO Structure Rules . . . 401

Lanthanides Experiments . . . 433

Qual Notes . . . 413

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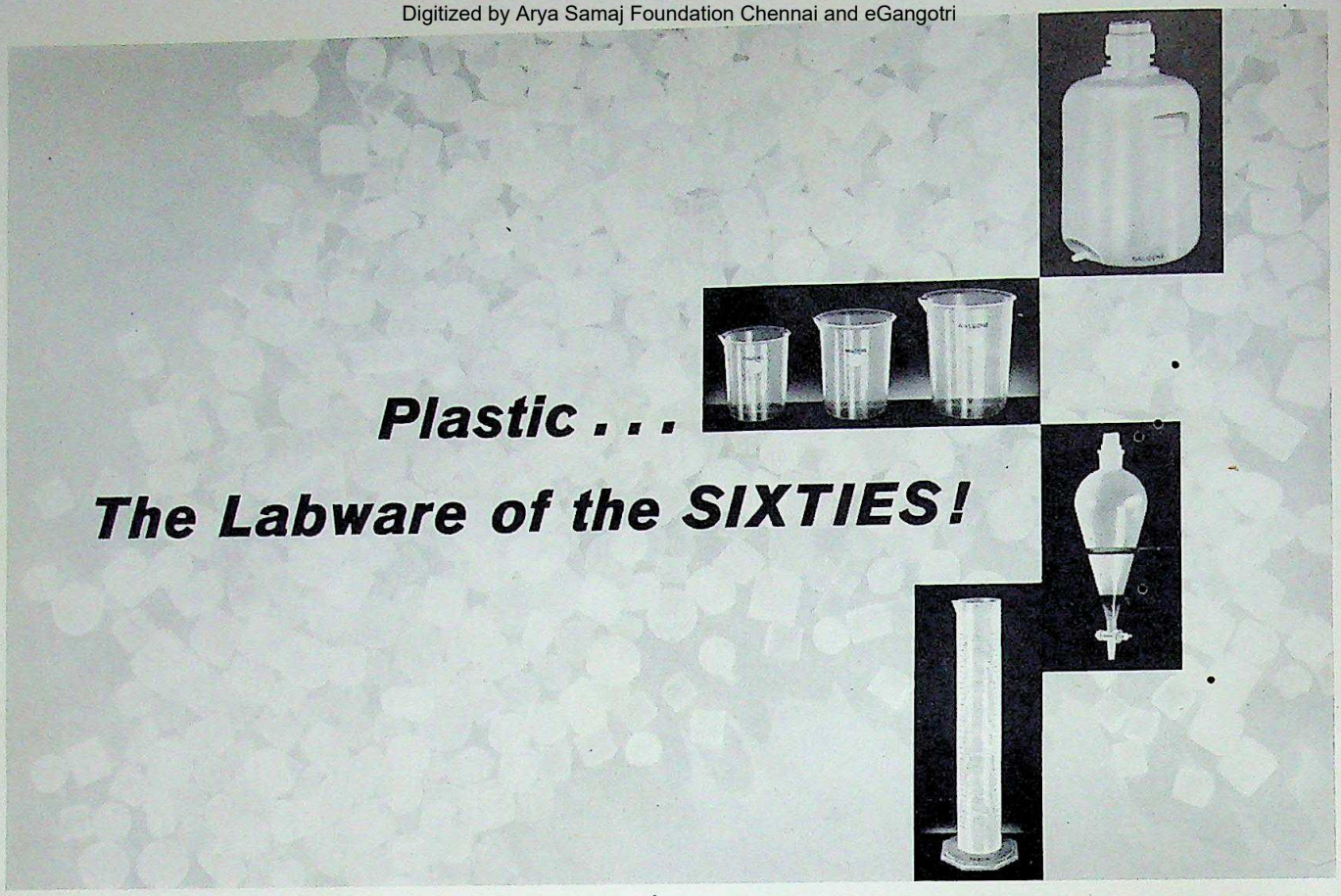

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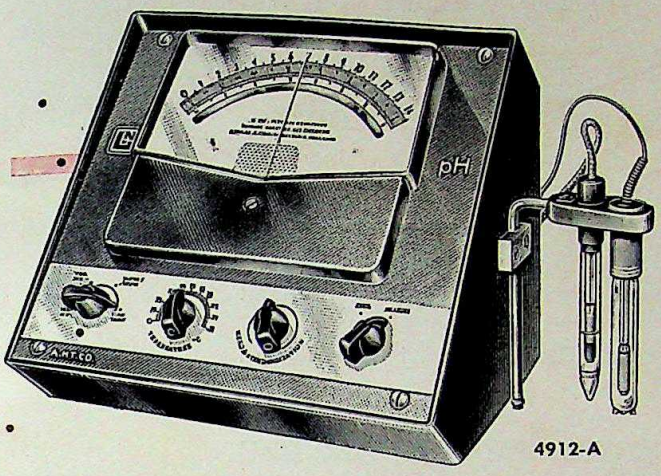

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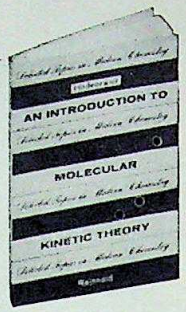

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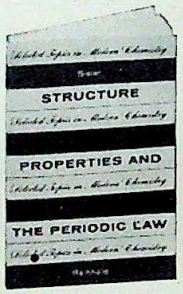

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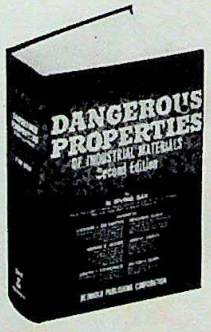

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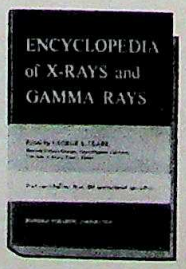

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JOURNAL OF Chemical Education

AUGUST 1963
Vol. 40 / No. 8

392 The Bromonium Ion, *James G. Traynham*
395 Demonstrating the Dynamic Behavior of Coupled Systems of Chemical Reactions, *R. M. Lago, J. Wei,* and *C. D. Prater*
401 Rules for Molecular Orbital Structures, *Herbert Meislich*
408 A Quantitative Experiment with Paper Chromatography, *W. Joe Frierson, Nina Marable,* and *Becky Bruce*
410 The Present and Future of Qualitative Analysis: Report of a Survey, *Nelson W. Hovey*

Notes on Qualitative Analysis

413 Separation and Identification of Copper in the Presence of Cadmium, *Aldicio Abrão*
414 Dissolving Difficultly Soluble Salts with Chelating Ion Exchange Resins, *Ronald Rich*
414 Non-Cyanide Detection of Cadmium, *R. L. Dutta* and *S. Dutta Choudhury*
415 A Simple Separation of the Group II-A Sulfides, *T. A. O'Donnell*
416 Preparation of Solutions for Qualitative Analysis with a Cation Exchange Resin, *Paul Key, Edward Sohl, Robert Tiews,* and *Clark Bricker*
417 Qualitative Detection of Ba, Sr, and Ca, Ions, *Richard Pariza*
417 Iodide Ion as a Qualitative Reagent: Detection of Nitrite and Sulfite, *Armine D. Paul* and *John A. Gibson, Jr.*

419 Control and Measurement of Water Activity, *S. D. Christian, H. E. Affsprung, J. R. Johnson,* and *J. D. Worley*
421 A Simple Kinetics Experiment for General Chemistry Laboratory, *W. H. Cone* and *R. A. Hermens*
422 Semimicro Modification of the Rast Method for Determining Molecular Weights, *E. J. Cowles* and *M. T. Pike*
423 High Pressure Techniques for Microscale Reactions, *Richard P. Rhodes*
425 A Small Fluidized-Solid Constant Temperature Bath, *Harry E. Weir* and *T. F. Rutledge*
426 Apparatus for Molecular Distillation and Vacuum Sublimation, *Bernard Loev, Kenneth M. Snader,* and *Minerva F. Kormendy*
427 Simple Evaporator for Heat Sensitive Compounds, *Charles R. Begeman*
428 Vacuum and Controlled Atmosphere Differential Thermal Analysis Apparatus, *Wesley W. Wendlandt*
430 Using Russian Technical Information, *J. G. Tolpin*
432 A Simple Pressure Stopcock, *Roger Gilmont*

Proceedings of the California Association of Chemistry Teachers:
433 The Lighter Lanthanides: Laboratory Experiments in Rare Earth Chemistry, *George B. Kauffman, Lloyd T. Takahashi,* and *R. C. Vickery*

438 Report of the New England Association of Chemistry Teachers: Stereochemistry in the Terminal Course, *Gordon G. Evans*

Features

391 Editorially Speaking
440 Letters
441 Book Reviews
A583 Out of the Editor's Basket
A599 Advertisers' Index
A575 TOPS in General Chemistry, *Hubert N. Alyea*
A593 Chem. Ed. Tested Demonstration, *Frederic B. Dutton*
A568 Program N. Y. Meeting
A549 Topics in Chemical Instrumentation. X. Continuous Analysis, *W. J. Blaedel* and *C. L. Olson*
A564 Chemical Projects, *Jay A. Young* and *John K. Taylor*

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These articles, most of which are to be contributed by guest authors, are intended to serve the readers of this JOURNAL *by calling attention to new developments in the theory, design, or availability of chemical laboratory instrumentation, or by presenting useful insights and explanations of topics that are of practical importance to those who use, or teach the use of, modern instrumentation and instrumental techniques.*

XI. Continuous Analysis

W. J. Blaedel *and* **C. L. Olson,** *Department of Chemistry, University of Wisconsin, Madison*

W. J. Blaedel is Professor of Chemistry at the University of Wisconsin. He received the B.A. and M.A. degrees at U.C.L.A. (1938, 1939), and the Ph.D. at Stanford (1942). He teaches elementary and advanced analytical chemistry, and does research in separations, continuous analysis and bioanalytical chemistry.

Carter Olson received his B.S. degree at Wisconsin State College, Stevens Point, Wisconsin in 1956. He received his Ph.D. from the University of Kansas in 1962, his research having been done in electrochemistry. He has been a project associate in chemistry at the University of Wisconsin for the last two years. In the fall of 1963 he will become assistant professor in the College of Pharmacy, Ohio State University, where he will teach instrumental analysis and do research in electrochemistry and continuous analysis.

For the purposes of this article, *continuous analysis* is defined to mean that kind of analytical procedure in which the sample is processed and measured as a flowing stream. If the original sample is not in the form of a flowing stream, it is converted to one prior to analysis. This definition is given to contrast with *repetitive analysis,* in which each sample is processed and measured individually, as a single batch. It should be pointed out that these two terms are used rather loosely in the analytical literature and are not generally given such specific meanings as they are in this article.

In a continuous analysis, various operations are first performed on the sample stream, in an effort to ready it for measurement, and then the measurement is made. Figure 1 illustrates a hypothetical case, involving addition of a reagent, heating to cause a reaction, solvent extraction to remove impurities, and finally measurement of the absorbance.

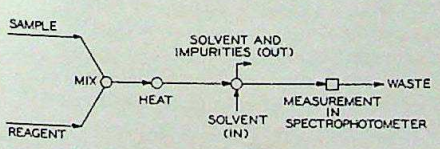

Figure 1 Schematic of a continuous analysis.

Two main advantages are associated with continuous analysis. First, automation is relatively easy in that transport is performed largely by the flowing stream; mechanical manipulation of the sample through the various steps in the procedure is minimized. The operations associated with continuous analysis are inherently simple. Second, the measurement system gives a continuous, steady state response which permits easy and frequent calibration of the instrument with a standard sample, after which unknown samples may be read out directly without intermediate readings or calculations of any sort. The need for automation and direct readout is becoming increasingly important in our burgeoning modern methods of analysis.

On the other hand, there are also limitations associated with continuous analysis. First, in order to minimize the time between introduction of the sample and readout of the result, holdup in the system should be as small as possible. Great ingenuity is required to minimize the sizes of the processing and measuring units. The system must be designed to prevent mixing between consecutive segments of the stream; otherwise an abrupt change is sample composition will not produce an abrupt change in the response, which will be smeared out.

Also, because of the time required to reach steady state, only a fraction of the total sample is actually utilized in making the measurement. This waste of sample corresponds to a loss of sensitivity. If high sensitivity is of paramount importance, the repetitive procedure is superior, since all of the sample may be utilized for measurement.

It must be emphasized that neither the continuous nor the repetitive approach to analysis is inherently superior; which is superior depends upon the particular application at hand, and upon the objectives of the analysis.

This article describes the present state of continuous analysis and its particular advantages. Restrictions in space do not permit a critical survey of the much more widely used repetitive procedures.

The Present State of Development of Continuous Analysis

Spurred principally by the needs of the chemical process industries, continuous flow measuring instruments are fairly well developed. Many concerns manufacture spectrophotometers equipped with flow cells having small holdup volumes—only a few hundredths of a milliliter in some cases. Equipment also exists for the measurement of temperature, pressure, flow rate, electrical and thermal conductivity, dielectric constant, magnetic susceptibility, current, voltage, refractive index, optical rotation, scattering, fluorescense, emission spectra, density, viscosity, sonic velocity, radioactivity, and particle size. All of these properties may be used for quantitative analysis.

There is a good number of familiar, simple, continuous analyzers that are based upon the measurement of these properties, and that accept the sample practically as is, with little or no processing (*9*). For the analysis of liquid streams, examples are the flame pho-

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tometer, and selective electrodes that measure concentrations of H^+, Ag^+, Cl^-, Na^+, and other ions. For gas streams, there are continuous analyzers for the determination of most gases, including H_2O and volatile organic compounds (*7, 9*).

While most of the novel instrumental properties may be measured easily and rapidly, they are subject to interferences; and their analytical use could be extended greatly by preceding the measurement with chemical preparation or separation steps. But in order that full benefit be derived from the speed and ease with which the measurement step may be performed, it is necessary to put any associated chemical operations on the same basis—that is, they must be speeded up and automated. An awareness is growing that automation of the preparation and separation steps can pay great dividends, not only in analysis for the processing plant, but also in the research laboratory, wherever analysis requires an appreciable fraction of the worker's effort. Continuous analysis is one way of achieving such automation.

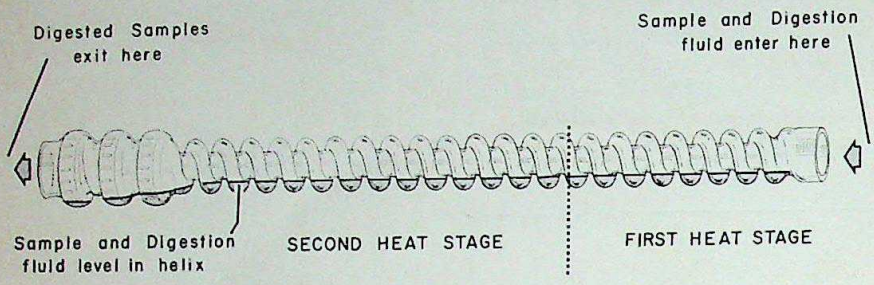


Figure 2. Vessel for continuous Kjeldahl digestion. (Reproduced with permission from Bulletin No. 461A, Technicon Controls, Inc., Chauncey, New York.)

There are several companies whose apparent objective it is to put complex analytical methods on an automated basis, and a few of these have chosen the continuous method, rather than the repetitive method.

The *Technicon Instruments Corporation* (Chauncey, New York) has been highly progressive in putting several unit analytical operations on a continuous basis. Equipment is available that performs the following operations on a flowing system: mixing of liquid streams, mixing and separation of gas-liquid streams, heating, solvent extraction, and dialysis. Figure 2 is a unit that digests samples continuously for the Kjeldahl method. The digestion vessel is a borosilicate glass tube grooved helically along its entire length. The vessel is rotated continuously and uniformly by a motor drive, so that material introduced at one end is spirally conveyed to exit at the other end.

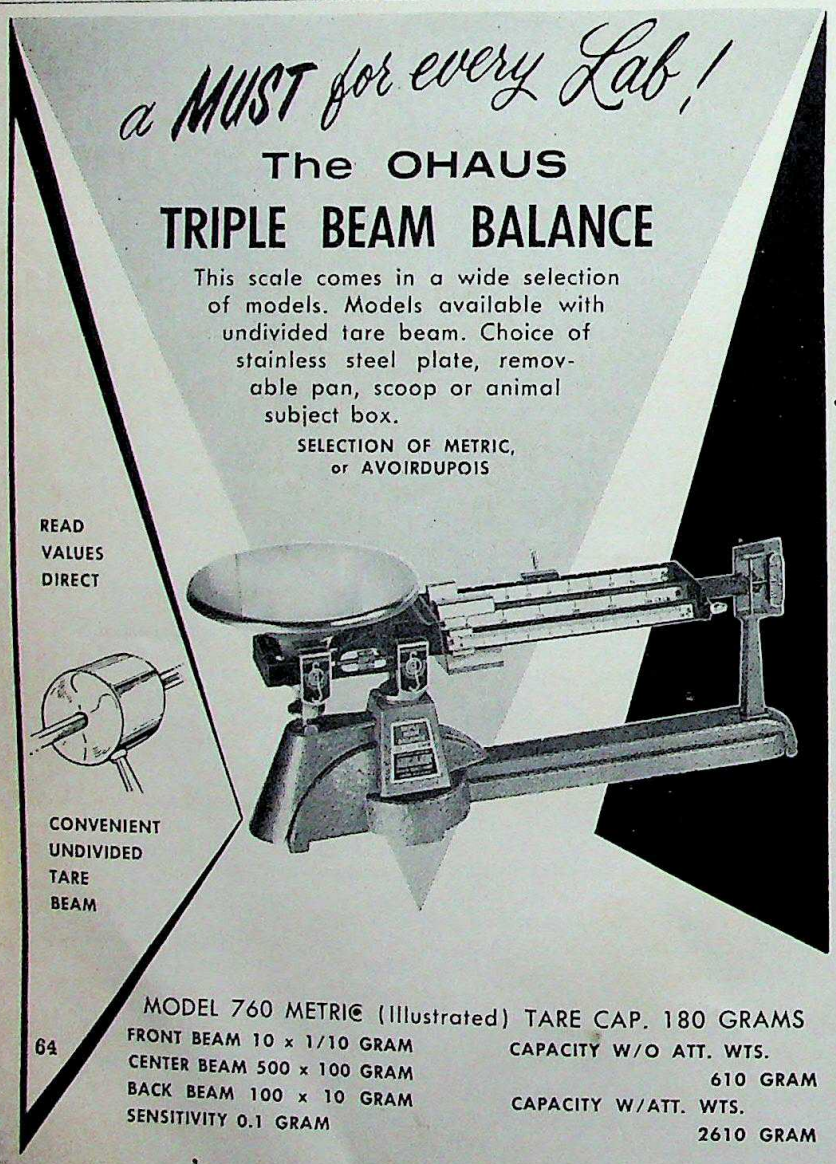
In general, sample and reagents are pumped with a multiple-channel peristaltic pump. Most measurements are made with a filter photometer, but some are made with a flame photometer. The measurement (absorbance or emission) is recorded continuously, and is related to the amount of sought-for substance in the sample. Calibration is performed very simply by running samples of known composition occasionally. Figure 3 is a diagram of a continuous method for nitrogen analysis by the Kjeldahl method, employing the continuous digestor shown in Figure 2. Twenty samples per hour may be run with this equipment.

In order to process samples at a high rate, each sample is not run to a steady state. Instead, each sample is run for a short predetermined time, followed by an interim of reagent alone, before introduction of the next sample. A maximum response is obtained for each sample, as depicted in Figure 3, the height of the maximum being related to the sample size. For many of the procedures, samples are run at the rate of 40 per hour.

Technicon markets its systems under the trade name of AutoAnalyzer. Several dozens of accepted analytical methods have been automated, many of them in the clinical field. Instruments are also available that perform several determinations on a single sample; an example is a system with four output channels that determines Na, K, CO_2, and Cl in blood serum.

A line of continuous reading analyzers is manufactured by the *Hach Chemical Company* (Ames, Iowa). These are low cost, monofunctional units that are designed principally for water analysis. In outline, sample and reagent are made to flow and mix under gravity, regulated by constant

(*Continued on page A552*)



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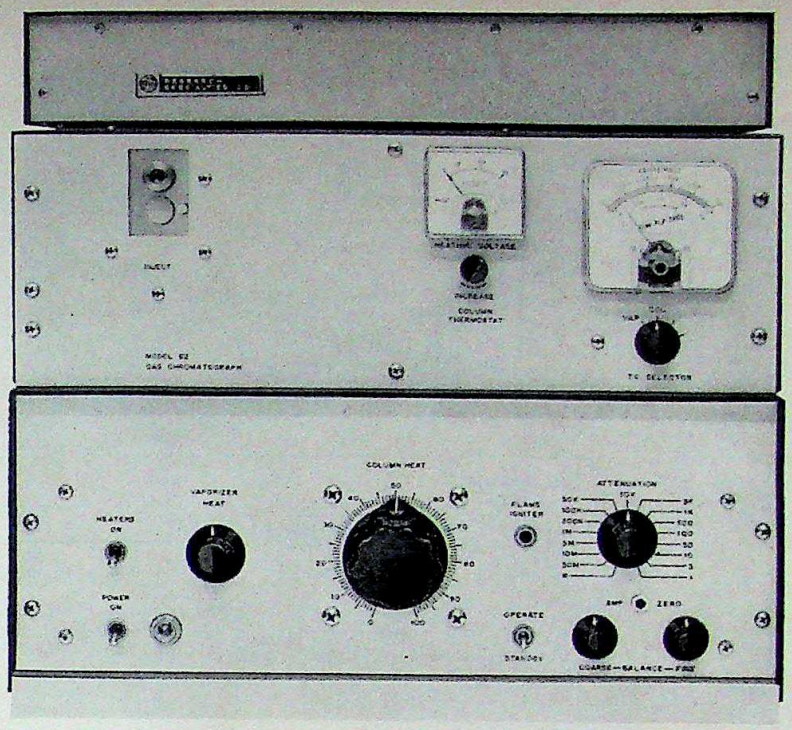

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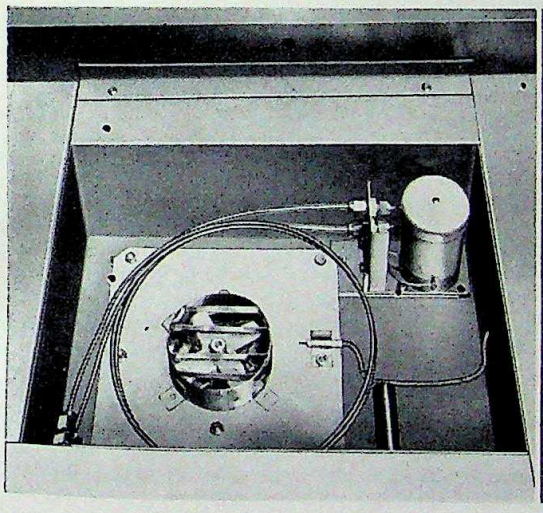

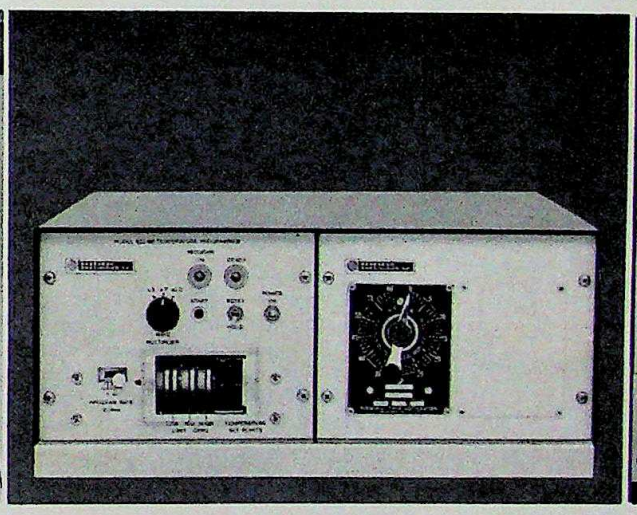

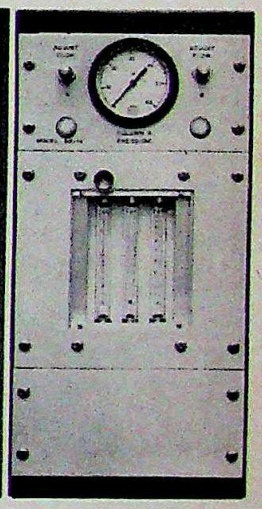

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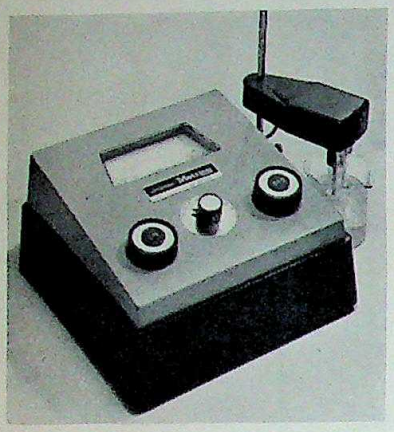

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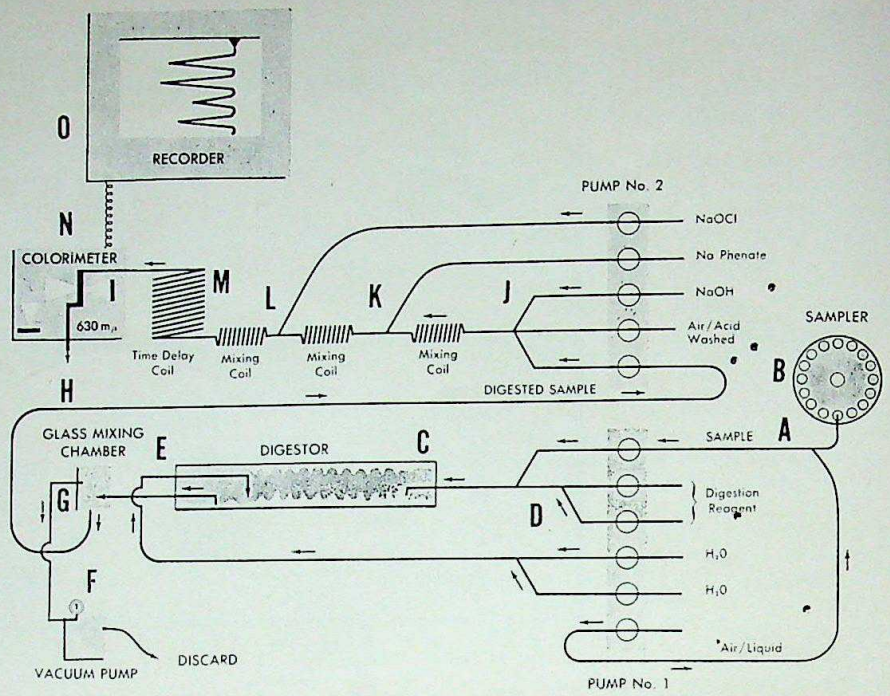

Figure 3. Continuous Analysis for Nitrogen by the Kjeldahl Method. (Reproduced with permission from Bulletin No. 461A, Technicon Controls, Inc., Chauncey, New York.)

"Channel *A* of Pump No. 1 aspirates sample from an automatic sample changer *B* into the Digestor Vessel C. Another channel *D*, also pumps a digestant into the vessel. Digestion occurs as the sample and digestant travel through two heat stages in the digestor vessel. On emerging from the second heat stage the digested material is continuously diluted with water, added via glass pipette *E*. The diluted digested material is then aspirated by a small vacuum pump *F*, into a glass mixing chamber *G*, where a turbulence of air bubbles within the chamber ensures thorough mixing. An aliquot of this dilution is pumped through channel *H* of Pump No. 2, as the remaining portion goes off to waste. The dilution is then joined with a stream of sodium hydroxide *J*, segmented by ammonia-free air. After mixing, the diluted material is joined by a stream of sodium phenate *K*, mixed, and then sodium hypochlorite *L*, is added and mixed *M*. After a time delay of approximately five minutes, an amount of blue color, directly proportional to ammonia, forms and is read by the flow Colorimeter *N*, at 630 mμ. A permanent record of the results is then produced in the Recorder O."

head devices. Pumps are not used. After mixing, the resultant stream flows through a filter photometer whose response is related to the concentration of sought-for substance in the sample stream. The schematic and legend of Figure 4 give greater detail. Continuous reading analyzers are available for the following analyses: residual chlorine (orthotolidine), fluoride (Zr-SPADNS), hardness (EDTA-Eriochrome Black T), *p*H (color indicator), silica (molybdate), and phosphate (molybdenum blue). Reagents are also supplied for these methods in quantities sufficient for 1–2 months of continuous operation without renewal.

Hach also makes a continuous titrator. Sample, titrant, and indicator flow by gravity, regulated in ways similar to those of Figure 4. However, the float valve that regulates the flow of titrant is driven by the photometer output always to keep the indicator around its end point color. The height of the titrant valve is read or recorded, and is related to the concentration of sought-for substance in the sample stream. The continuous titrator is used for total hardness (EDTA titrant) and alkalinity (standard acid titrant).

Hagan Chemicals & Controls (Pittsburgh, Pennsylvania) offers the Chemonitor, an instrument that mixes sample and reagents with a peristaltic pump, heats the resultant stream to produce a color, and measures and records the absorbance. Provision is made for periodic flushing and zeroing, and also for periodic calibration with a standard solution. A block diagram summarizes these features in Figure 5. The Chemonitor has so far been applied principally to water analysis. Typical determinations are for silica, total hardness, iron, and copper. Hagan also supplies reagents for these determinations. Multipoint analysis of up to four streams is provided optionally, with an analysis rate of $7^1/_2$ min per stream.

Future Developments

The wide application of continuous analysis must await wider availability and further development of equipment. Such development is underway.

In addition to the instruments mentioned above, equipment is available for continuous electrophoresis, both on paper (Beckman Instruments, Spinco Division, Palo Alto, California) and in carrier-free buffered solution (Brinkmann Instruments, Inc., Great Neck, New York).

Several stripping devices with low holdup and rapid response are described in the literature. To determine traces of water in an organic liquid, the liquid is

(*Continued on page A554*)

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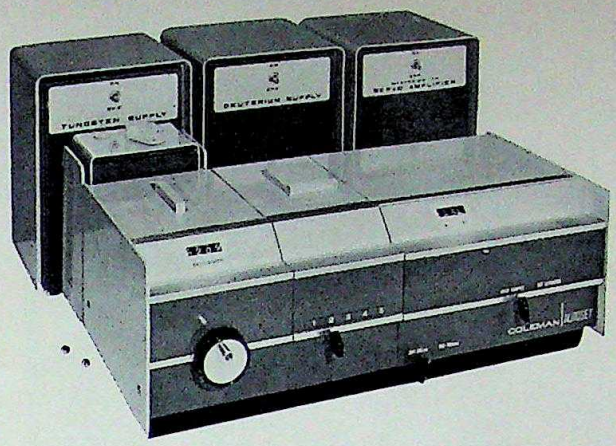

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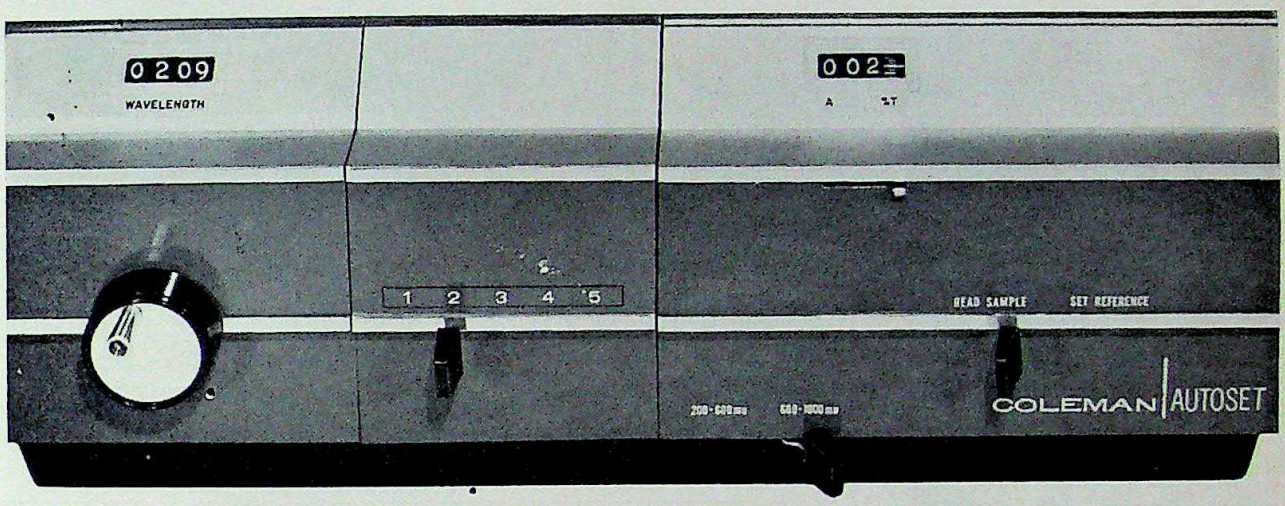

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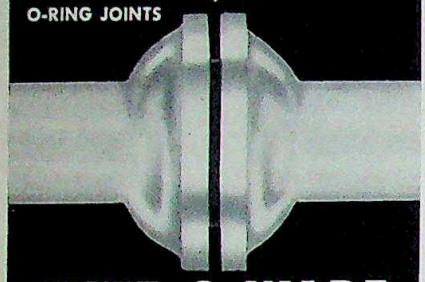

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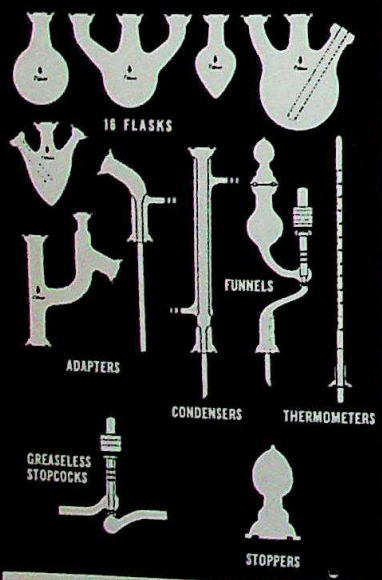

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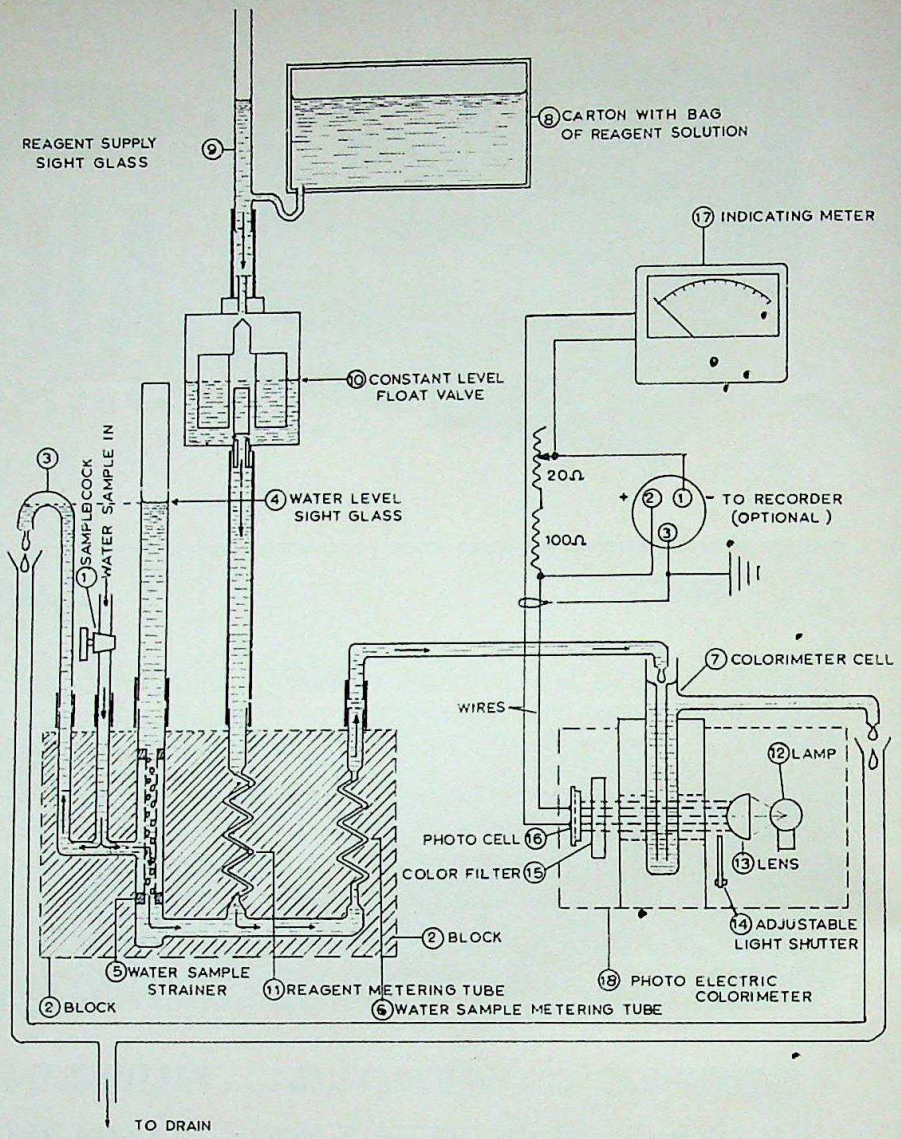

Figure 4. The Hach Continuous Reading Analyzer. (Reproduced with permission from the Hach Chemical Co., Ames, Iowa.)

"The analyzer is connected to the water supply system at the point where it is desired to take the water sample for analysis, with the use of a sample cock (1). The cock is adjusted so that approximately 100 ml. per minute of water sample flows to the analyzer. The sample enters the Block (2) and most of the water flows to the water head regulator (3) where it overflows and goes to the drain. The Water Sample Head Regulator maintains a constant head of water which is shown on the Water Sample Sight Glass (4). The water sample flows through the Water Sample Strainer (5) and then through the Water Sample Metering Tube (6). The diameter and length of this tube is such that a water flow rate of 5 ml. per minute takes place with the water head shown in Sight Glass (4). From the water metering tube (6), the sample is delivered to the Colorimeter Cell (7).

The color developing reagent is contained in a carton with a polyethylene bag liner (8), which is connected to a Reagent Supply Sight Glass (9), and a constant level Float Valve (10). From the Float Valve, the reagent flows to the Reagent Metering Tube (11). The length and diameter of this tube is such that a reagent flow rate of .1 ml. per minute takes place. The Reagent Metering Tube (11) connects to the water system so that the reagent solution stream mixes with the water sample stream.

A color develops in the water sample as a result of the addition of the color developing reagent, and the colored sample flows to Colorimeter (18), where it drips into the Colorimeter cell (7). The action of dripping the sample mixes the sample in the cell so that an accurate color measurement can be made. The cell overflows to the drain and thus remains level full at all times.

The color that is developed is measured continuously by the Photo-Electric Colorimeter (18), which consists of a Lamp (12), a Lens (13), an Adjustable Light Shutter (14), Colorimeter Cell (7), Color Filter (15) and Photoelectric Cell (16). The electric voltage output from the photocell is measured by an Indicating Meter (17) which is calibrated to give a direct reading of the analysis of the water sample. A recorder can be connected to record the analysis if desired.

The above illustration shows the simplest CR Colorimetric Analyzer, such as an analyzer for Residual Chlorine by the orthotolidine method, and pH by colorimetric indicator method. The same general arrangement is used for the hardness alarm monitor, except that a photoelectric relay to operate a switch is used instead of the indicating meter.

In the case of the fluoride analyzer, two different reagent solutions are used, and are added to the water sample successively."

(*Continued on page A556*)

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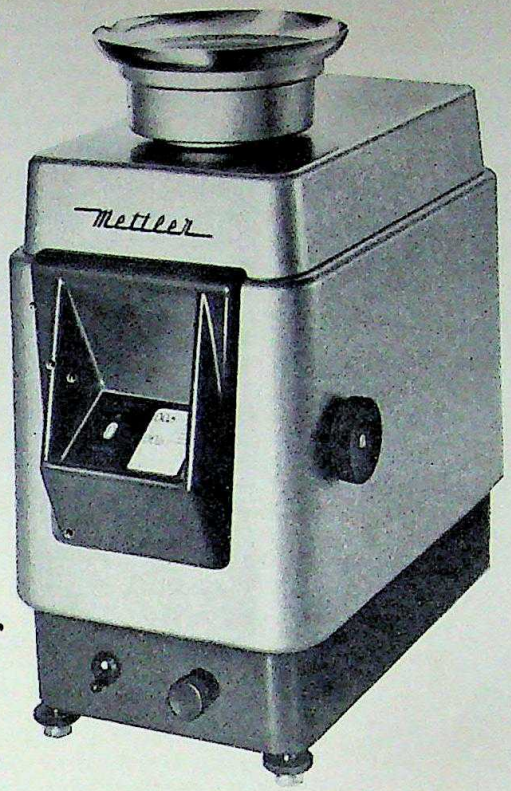

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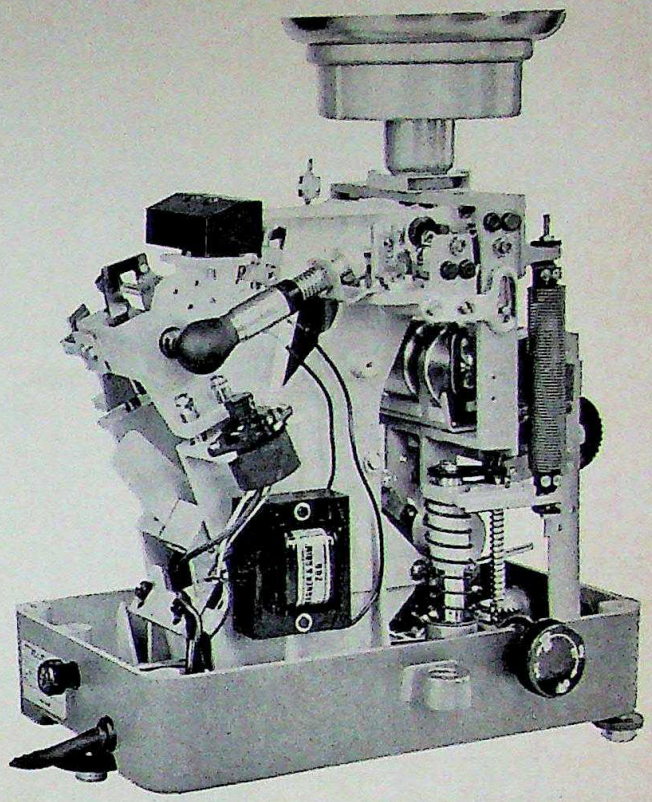

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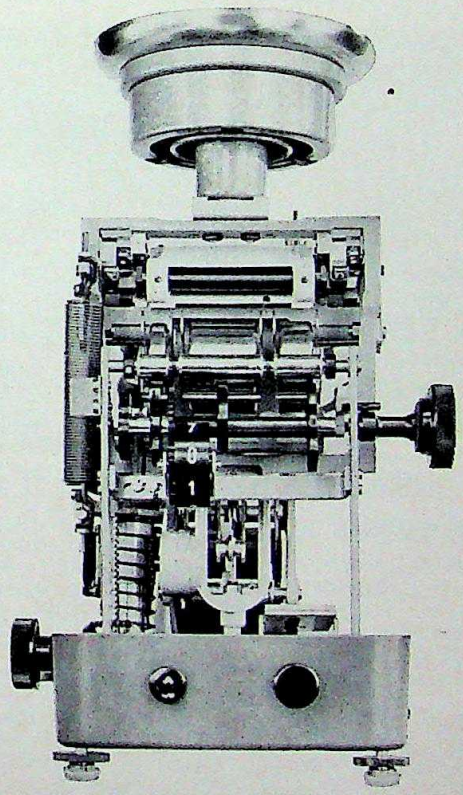

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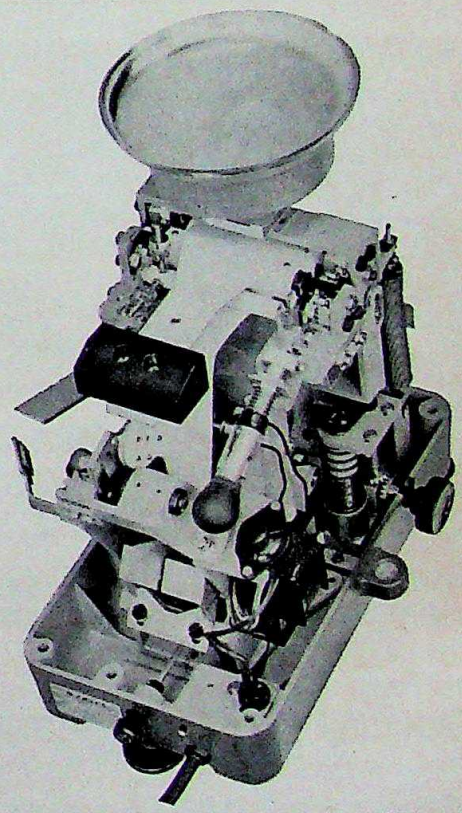

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allowed to fall in a column, while water is extracted into a countercurrently upward-flowing stream of nitrogen. The water in the gas phase is then determined electrolytically (*5*). In another stripper, oxygen can be removed from aqueous solution prior to polarographic analysis with a cocurrent high velocity stream of nitrogen in a capillary tube (*4*).

A recent version of a continuous countercurrent solvent extraction column with moderately low holdup has been described (*10*).

Still needed is improved equipment with low holdup and rapid response for solvent extraction, evaporation, separation of solids from liquids (i.e., centrifugation, filtration, or settling), combustion, continuous titration, and other analytical operations.

Most of the present continuous analyzers are based upon the measurement of absorbance with a filter photometer, possibly because of the fine state of near-perfection to which the art of photometer cell design has been developed. A wide variety of electrode types and materials is rapidly improving electrochemical measurements. A cell with a holdup below 0.1 ml has been described that permits measurements with a dropping mercury electrode in flowing solutions (*3*). A tubular platinum electrode with a holdup below 0.01 ml that can detect electroactive materials at concentrations below 10^{-7} *M* in flowing solutions was described (*2*).

It is interesting that some investigators have built continuous flow systems for highly specific purposes—a testimonial to the growing recognition of the unique advantages of the continuous method. A few examples of such work follow.

Zlatkis and co-workers have built a continuous flow system for the analysis of small aqueous samples of non-volatile aminoacids by gas chromatography (*11*). The aminoacids are first oxidized at 140°C to volatile aldehydes in a small reactor (6 × 1/4 in. column, filled with ninhydrin-impregnated firebrick). The aldehydes are transferred by hydrogen carrier gas to the chromatographic column, where they are separated. After leaving the column, the aldehydes are cracked at 425°C to methane and water in another reactor (12 × 1/4 in. column, filled with a nickel-kieselguhr catalyst). Water is removed in a third column (12 × 1/4 in., filled with a molecular sieve), and the methane is detected in a thermal conductivity cell.

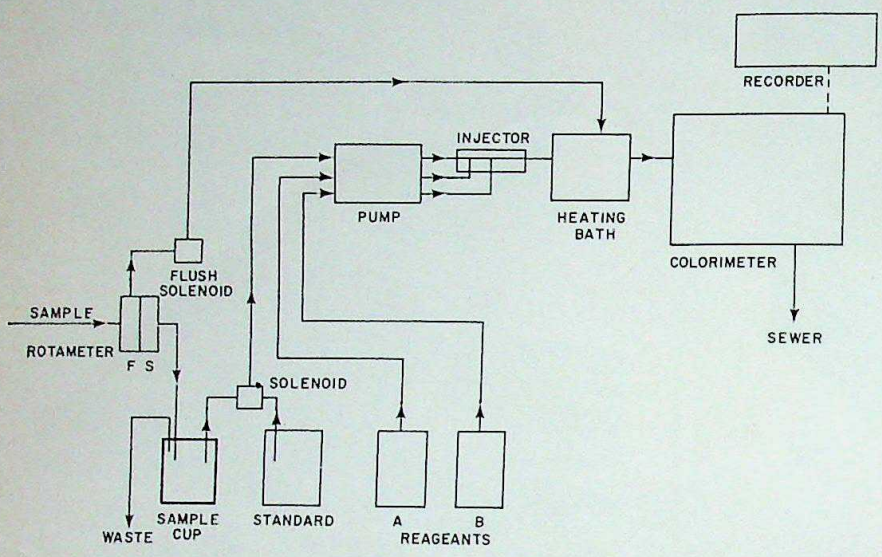

Figure 5. The Hagon Chemonitor. (Reproduced with permission from Hagan Chemicals and Controls, Pittsburgh, Pennsylvania.)

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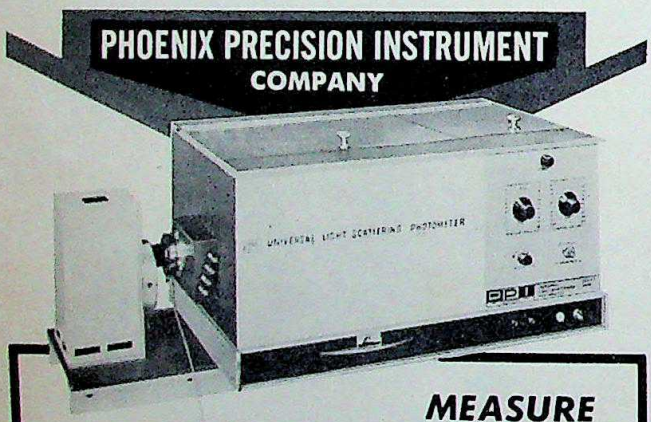

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Drawert and co-workers have devised a similar method for small samples of aqueous alcoholic solutions, which are converted in a small reactor to olefins (*6*). The olefins are carried by a stream of hydrogen to the gas chromatographic column, where they are separated more easily than the original alcohols.

Greenfield and Copper have designed a continuous analyzer for the determination of hypophosphite in electroless plating solutions (*8*). The hypophosphite is converted at room temperature in the presence of palladium black to phosphite and hydrogen gas. The hydrogen is separated from the solution in a stripper and burned in a microburner beneath a thermocouple. The thermocouple output is recorded and taken as a measure of the hypophosphite content of the solution. Calibration is performed with standard hypophosphite samples or a stream of hydrogen introduced to the burner through a flowmeter. Hypophosphite centents of about 2% may be determined with relative errors that appear to be of the order of a few percent or less.

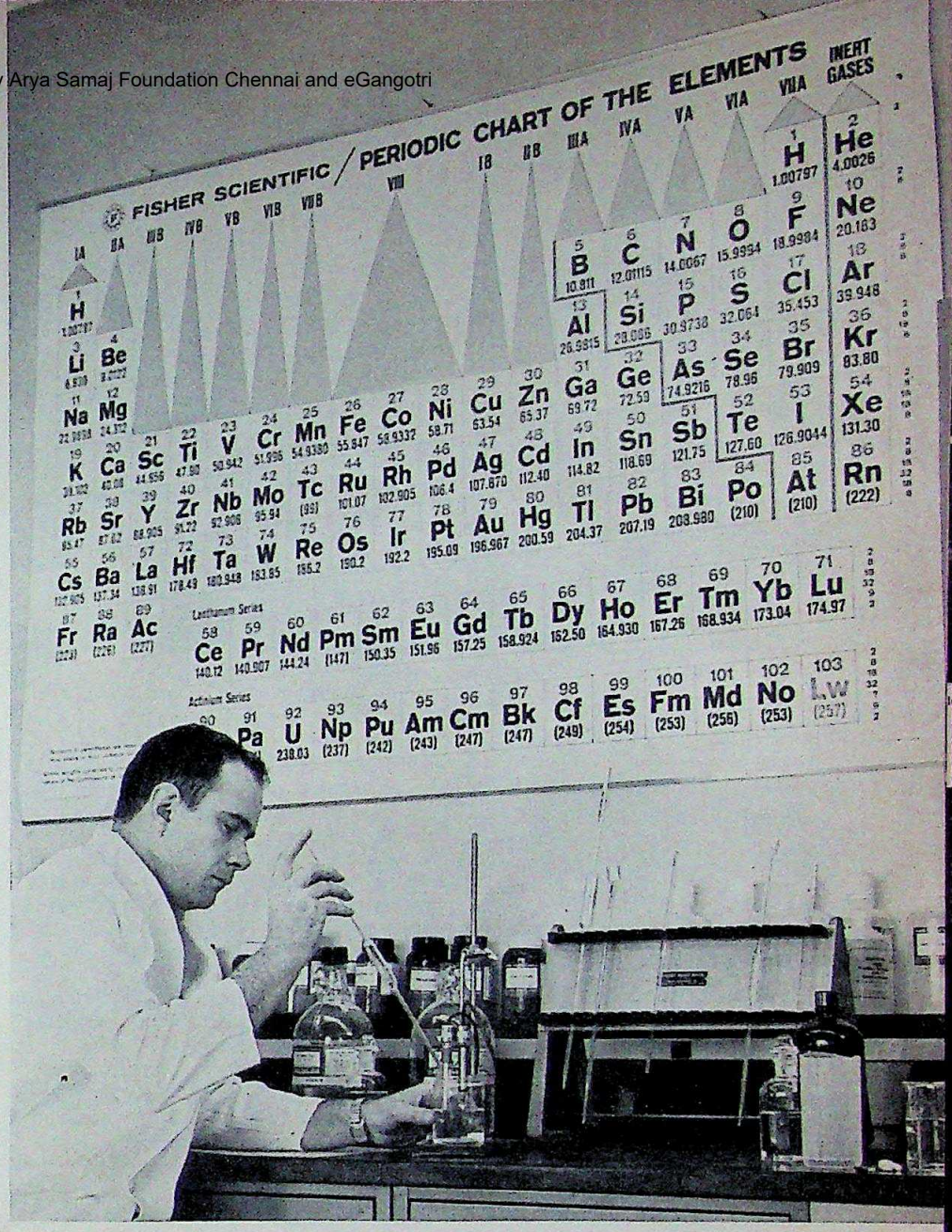
In a third example, Blaedel and Hicks determine enzyme concentrations with equipment that continuously measures the rate of chemical reaction (*1*). A stream of the enzyme sample is metered into a metered reagent stream that contains controlled and non-limiting concentrations of all substrates and other reagents necessary for a color-forming reaction that is catalyzed by the enzyme. After mixing, the reacting stream flows at a constant rate through two microcolorimeter cells that are placed at a fixed distance apart on the stream. The absorbance difference between the two cells is measured and recorded with a very sensitive differential filter photometer (0.01 absorbance unit full scale). The photometer output is directly proportional to the absorbance difference between the two cells, and therefore also to the enzyme concentration in the sample stream. After calibration with a standard sample, the enzyme concentration in a sample may be read out directly. Application has been made to the determination of lactate dehydrogenase and transaminase in serum, and also to a substrate, glucose.

The above examples are given because an important and final conclusion may be drawn from them. When thought of in terms of conventional batch operations, these methods are not feasible—they seem hopelessly time consuming, non-reproducible, or laborious. On a continuous basis, however, the difficulties are minimized, and the methods are feasible. In other words continuous analysis will add to our analytical repertory by making feasible new methods of analysis based upon operations and measurements that are not now feasible by the more conventional batchwise procedures.

Literature Cited

(1) Blaedel, W. J., and Hicks, G. P., *Anal. Biochem.*, 4, 476 (1962).

(*Continued on page A558*)



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(2) Blaedel, W. J., and Olson, C. L., *Anal. Chem.*, in press.

(3) Blaedel, W. J., and Strohl, J. H., *Anal. Chem.*, in press.

(4) Blaedel, W. J., and Todd, J. W., *Anal. Chem.*, **30**, 1821 (1958).

(5) Cole, L. G., Czuha, M., Mosley, R. W., and Sawyer, D. T., *Anal. Chem.*, **31**, 2048 (1959).

(6) Drawert, F., Felgenhauer, R., and Kupfer, G., *Angew. Chem.*, **72**, 555 (1960).

(7) Fraade, D. J., *Instruments and Control Systems*, **34**, 2059 (1961).

(8) Greenfield, S., and Cooper R. M., *Talanta*, **9**, 483 (1962).

(9) Siggia, S., "Continuous Analysis of Chemical Process Systems," John Wiley and Sons, **1959**, New York.

(10) Williams, D. D., and Miller, R. R., *Anal. Chem.*, **34**, 657 (1962).

(11) Zlatkis, A., Oro, J. F., and Kimball, A. P., *Anal. Chem.*, **32**, 162 (1960).

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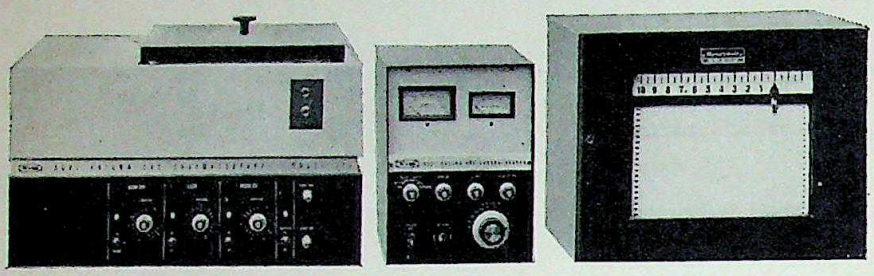

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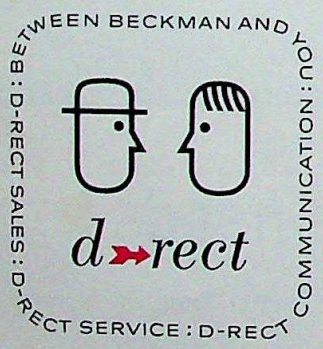

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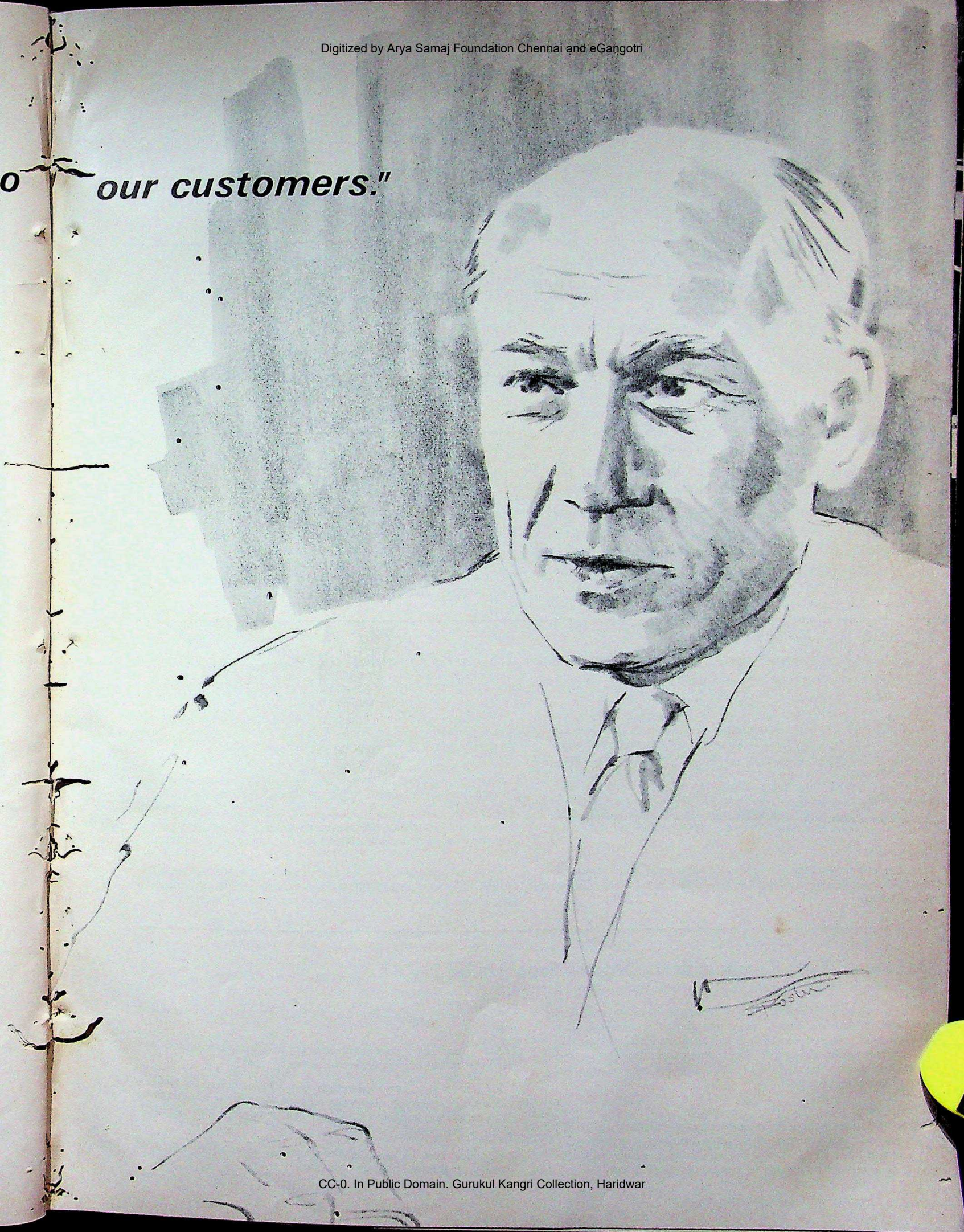

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Compiled by **JAY A. YOUNG,** King's College, Wilkes-Barre, Penna.
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Rapid Detection of Cations of Copper Group

See CHANDRA, R., *J. Chem. Educ.*, **38**, 413 (1961).

This scheme for the detection of the cations in the copper group is based upon the preferential reduction of mercury(II) ions by metallic copper, the relative insolubility of $BiPO_4$ in acidic solution, and the selective reduction of copper(II) ions to metallic copper by sodium dithionite in ammoniacal solution.

Questions:

What are the limiting concentrations of ions required by this procedure?

What ions interfere with the separations and identifications described in this article? Can some or all of these interferences be eliminated by modifying the procedure?

Non-Cyanide Detection of Cadmium in the Presence of Copper

See CHANDRA, R., *J. Chem. Educ.*, **38**, 409–10 (1961).

In this article six different methods for the separation of copper and cadmium are described. The methods are empirical; for five of them the reactions which occur are not described, though plausible possibilities are briefly discussed. See also the letter to the editor, **38**, THIS JOURNAL 638 (1961).

Question:

Select any one of the six methods and determine the reactions which occur when the procedure is carried out. (Or, for the third method, since the equation for the major reaction is given, confirm this equation or suggest another which is consistent with the data you obtain.)

A New Qualitative Reagent for Aluminum. A Specific Qualitative Reagent for Copper

See JONES, C. T., AND WILLIAMS, M. B., *J. Chem. Educ.*, **38**, 411 (1961) and WILLIAMS, T. R., AND BURTON, F., *J. Chem. Educ.*, **38**, 413 (1961).

In the first article, the authors report that arsenazo reagent (available commercially) is superior to Aluminon as a specific test for aluminum. A reddish-purple color results when a solution of arsenazo reagent is added to a solution containing aluminum ions.

In the second article, the precipitation at *p*H's near neutrality of a green compound formed when a solution of *o*-(*p*-toluylsulfonamide) aniline is added to a solution containing copper(II) ions is described. Cadmium does not interfere.

Questions:

Select either test, for aluminum or for copper, and determine the reactions which occur and the products formed when the test is performed.

Will any other compounds, similar to the arsenazo reagent, also react with aluminum ions, or other ions, to provide a distinctive test for aluminum or the other metal ion?

Can any compounds similar to *o*-(*p*-toluylsulfonamide) aniline be used as specific reagents for copper or other metal ions?

Why, do you think, the arsenazo reagent is superior to the commonly used Aluminon reagent for the detection of aluminum?

Can you account for the fact that *o*-(*p*-toluylsulfonamide) aniline does not react with cadmium ions, and is, therefore, a suitable reagent for distinguishing copper from cadmium?

Benzenoid Nitro Compounds as Organic Reagents for Tin(II)

See BURNS, R. L., AND GRUEN, F. M., *J. Chem. Educ.*, **38**, 410–11 (1961).

Three different benzenoid nitro compounds—the dye, naphthol yellow-S, 2,4-dinitrophenol, and meta-dinitrobenzene—all give characteristic colored compounds in the presence of the tin(II) ion. Presumably, the tin(II) ion reduces the nitro groups and then chelates with the reduced product to form a colored complex, though this is not certain.

Questions:

What is the reaction or reactions which take place when tin(II) ion reacts with any one of the three nitro compounds mentioned?

Can you find any other nitro compounds which will also serve as qualitative organic reagents for tin(II) ion? If so, identify the products formed and determine the reactions which occur.

Are there any other reducible organic reagents which will also serve as identifying reagents for tin(II) ion?

Are there any other inorganic ions, in addition to tin(II), which will reduce, or otherwise react with, nitro compounds to produce a characteristic result that can be used to identify these ions?

Can this test be used in the converse way, as a means of identifying different organic unknowns?

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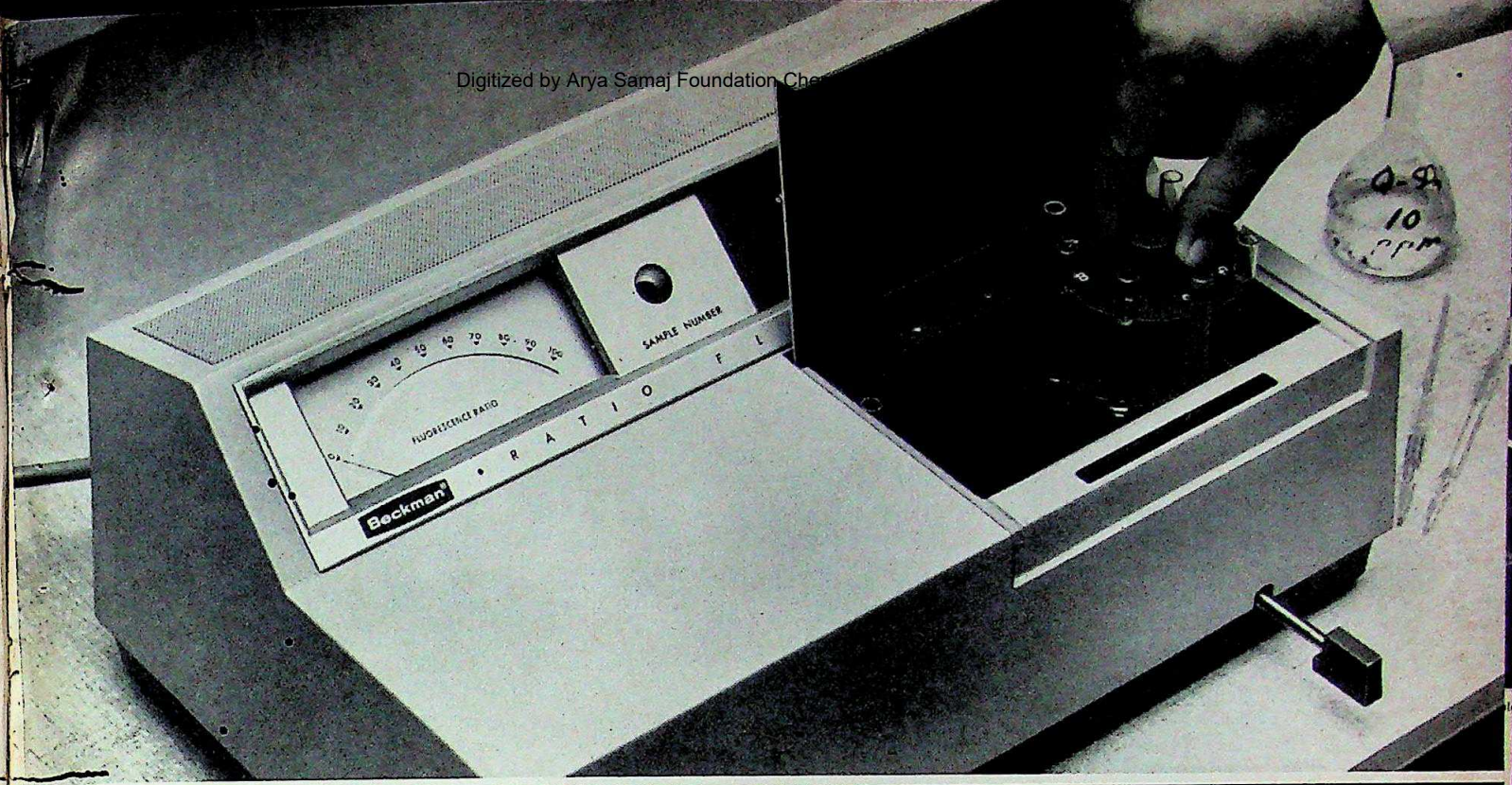

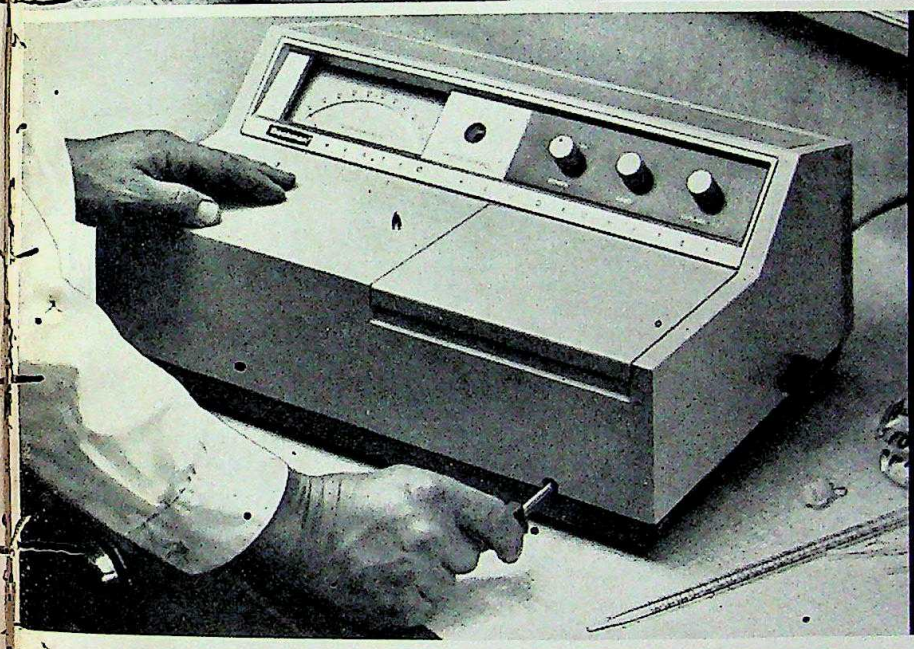

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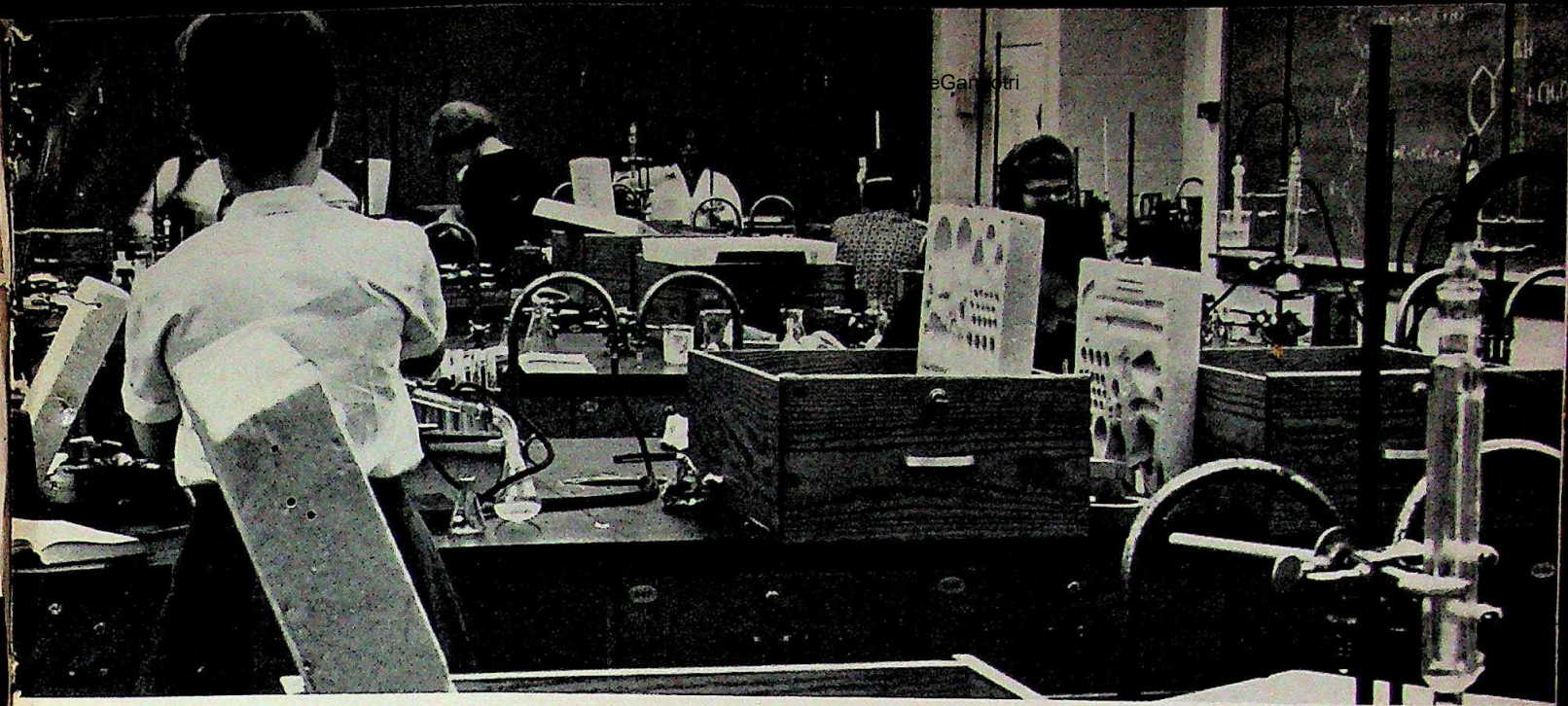

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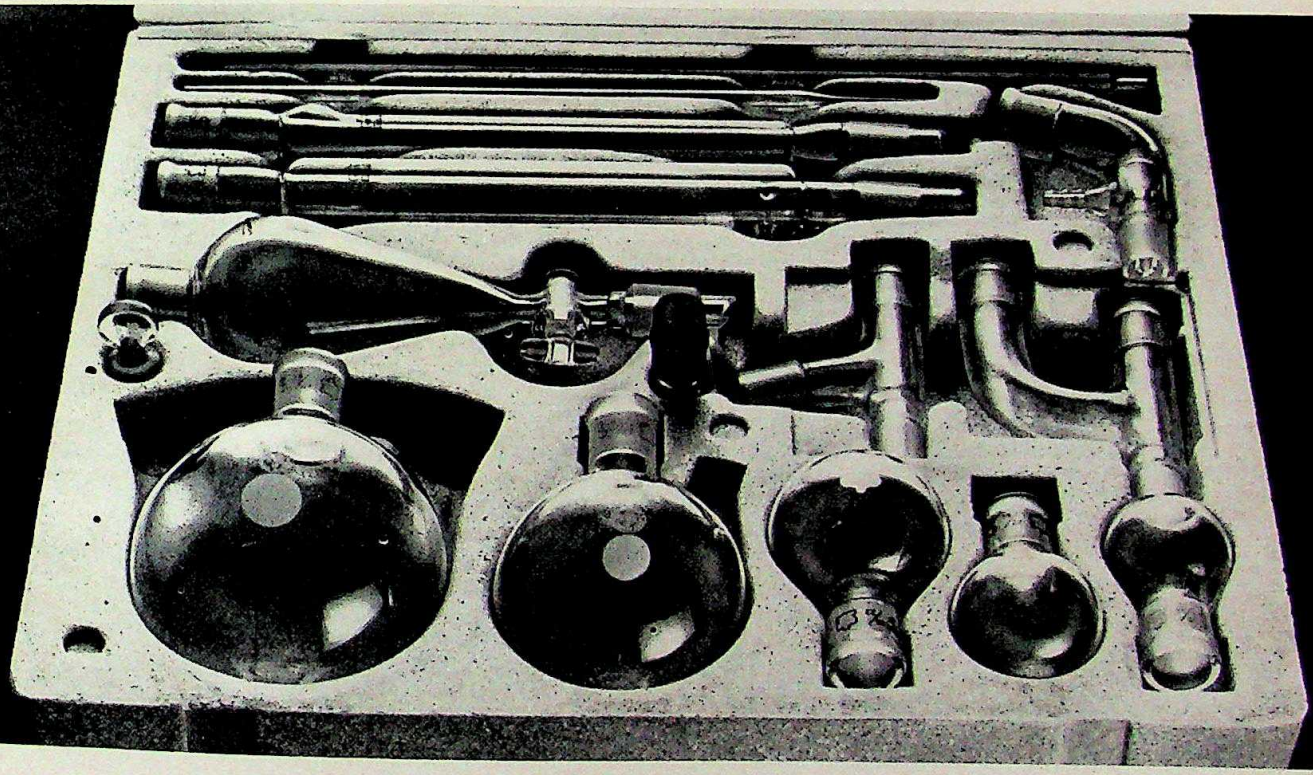

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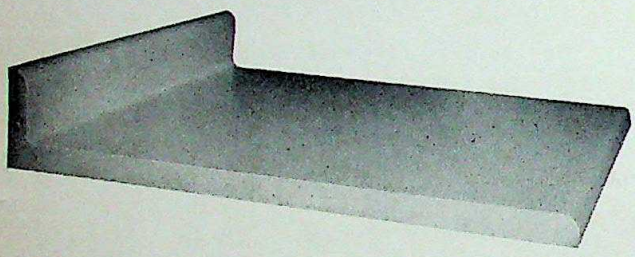

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Program for New York Meeting ACS Division of Chemical Education

Edward C. Fuller, Chairman
Robert L. Livingston, Secy

MONDAY, September 9

Symposium on Education and Training in Cellulose, Wood, and Fiber Chemistry

(Joint with Division of Cellulose, Wood, and Fiber Chemistry)

E. C. Jahn, *Presiding*

9:30— **T. E. Timell.** Introducing the Symposium.
9:35— **E. C. Jahn.** Introductory Remarks.
9:40— 1. **W. M. Hearon.** Career Opportunities in Pulp and Paper and Wood Industries.
10:05— 2. **E. E. Dickey.** Teaching Cellulose and Hemicellulose Chemistry.
10:35— 3. **Alfred J. Stamm.** Fundamental Physical Approach to Wood and Cellulose Science.
11:05— 4. **Arthur B. Anderson.** The Emergence of Education in Forest Chemistry at Berkeley.
11:30— 5. **H. W. Giertz.** The European Approach to Education in Cellulose, Wood and Fiber Chemistry.

J. L. McCarthy, *Presiding*

2:00— **J. L. McCarthy.** Introductory Remarks.
2:05— 6. **Kyosti V. Sarkanen.** Teaching Lignin, Terpene and Extractive Wood Chemistry.
2:35— 7. **W. A. Côté, Jr.** Teaching of Structure and Ultrastructure of Wood Fibers.
3:05— 8. **V. T. Stannett.** Role of Polymer Chemistry in Education of Cellulose, Wood and Fiber Chemists.
3:35— 9. **Conrad Schuerch.** Forest Chemistry: Its Role in a Forestry College.
4:05—10. **Ludwig Rebenfeld.** Education in Cellulose and Fiber Chemistry for the Textile Industry.

TUESDAY, September 10

Symposium on Recent Trends in Undergraduate Chemistry Curricula

L. Carroll King, *Presiding*

9:00— 1. **L. Carroll King.** Introductory Remarks.
9:10— 2. **Richard J. Ketes, Donald H. Andrews.** The Undergraduate Chemistry Curriculum at The Johns Hopkins University.
10:00— 3. **Richard C. Bowers.** The Impact of Freshman Chemistry Course Revisions on the Analytical Chemistry Curriculum.
10:50— 4. **Gerald R. Bakker, O. Theodor Benfey, Wilmer J. Stratten, Laurence E. Strong.** The Earlham Chemistry Curriculum—Conceptualizing Chemistry.
11:40— General Discussion.

William B. Cook, *Presiding*

2:00— 5. **William B. Cook.** Introductory Remarks.
2:10— 6. **Robert C. Brasted.** The General Chemistry Program at the University of Minnesota.
3:00— 7. **Edward C. Fuller.** Combining First Year College Chemistry and Physics.
3:50— 8. **A. K. Colter.** A Sophomore-Level Course in Valence and Molecular Structure.
4:40— General Discussion.
6:30— Social Hour. Fordham University Campus Center (Ramskeller).
7:30— Divisional Dinner. Fordham University Campus Center (Ramskeller). Speaker: Walter H. Brattain, Nobel Medalist. Subject: Recent Developments in Semiconductor Surface Phenomena.

(Continued on page A570)

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Mercury ⊙ Molybdenum ⊙ Nickel ⊙ Palladium ⊙ Platinum ⊙ Potassium ⊙ Rhodium ⊙ Rubidium ⊙ Selenium
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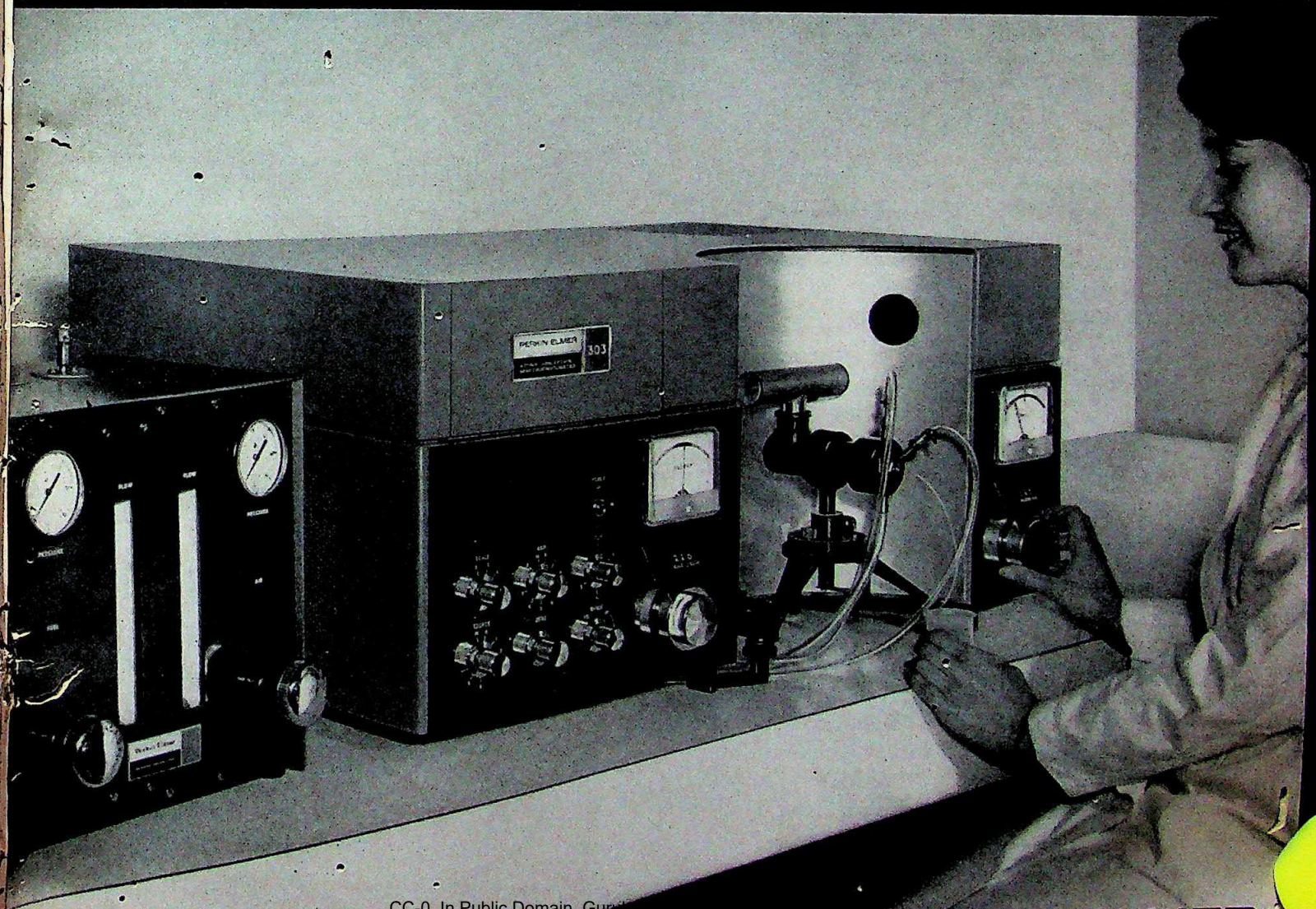

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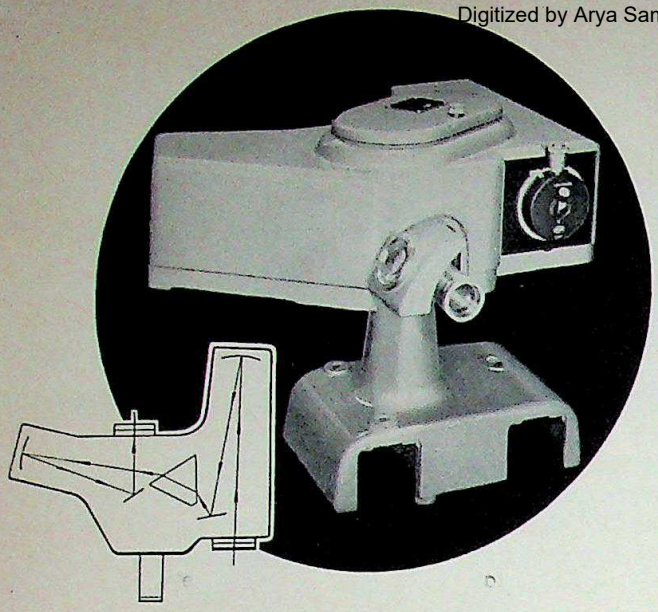

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WEDNESDAY, September 11

General

Fred B. Dutton, *Presiding*

9:00— 9. **Fred B. Dutton.** Introductory Remarks.
9:05—10. **Richard G. Yalman.** Chemistry Education in the Small Liberal Arts College: A Program for Tomorrow.
9:30—11. **Paul H. Carnell.** An Experiment in Ability Grouping in Freshman College Chemistry.
9:50—12. **James R. Stebbins.** What Happens to a Poorly Prepared Chemistry Student?
10:15—13. **Nelson W. Hovey.** The Present and Future of Qualitative Analysis—Report of a Survey.
10:50—14. **Frederick R. Greenbaum.** The Teaching of Radioisotopes in a Technical High School.
11:10—15. **H. Bradford Thompson.** A Laboratory for Modern Freshman Chemistry.
11:45— Divisional Business Meeting.

Harold E. Wilcox, *Presiding*

2:00—16. **Harold E. Wilcox.** Introductory Remarks.
2:05—17. **LeRoy I. Braddock.** Buoyancy Corrections for a Single-Pan Analytical Balance.
2:25—18. **Ruth A. Walker.** "Active" General Chemistry Visuals for the Overhead Projector.
2:45—19. **Molly S. Geller.** Three Studies Using Programmed Instruction in Introductory Organic Chemistry.
3:15—20. **Solomon Marmor.** Experimental Experiments in the Undergraduate Organic Laboratory.
3:30—21. **Eugene M. Holleran.** Common Misconceptions About Imperfect Gases.
3:45—22. **G. J. Beichl.** Caratheodory's Principle.
4:05—23. **L. Carroll King.** A Molecular Model System: When Bond Lengths Are Defined, Bond Angles Are Predicted.
4:25—24. **R. H. Petrucci.** Three-Dimensional Models in Phase Rule Studies.

THURSDAY, September 12

Symposium on Recent Advances in Instrumental Methods of Analysis

(*Joint with Division of Analytical Chemistry*)

9:00—25. **Seymour Z. Lewin.** Introductory Remarks.
9:10—26. **Edward S. Sayre.** Current Radiochemical Methods of Analysis.
9:50— Discussion.
9:55—27. **Irving Shain.** Electroanalytical Instrumentation.
10:35— Discussion.
10:40—28. **Edward Bunnenberg.** Optical Rotatory Dispersion and Circular Dichroism.
11:20— Discussion.
11:25—29. **Saul Gordon.** Thermoanalytical Techniques.
12:05— Discussion.

Seymour Z. Lewin, *Presiding*

2:00—30. **W. E. L. Grossman, W. D. Cooke.** Flame Spectroscopy.
2:40— Discussion.
2:45—31. **George K. Fraenkel.** Electron Spin Resonance.
3:25— Discussion.
3:30—32. **Lewis Friedman.** Mass Spectrometric Techniques.
4:10— Discussion.
4:15—33. **Joseph Glickstein.** Differentiation and Integration Methods.
4:55— Discussion.

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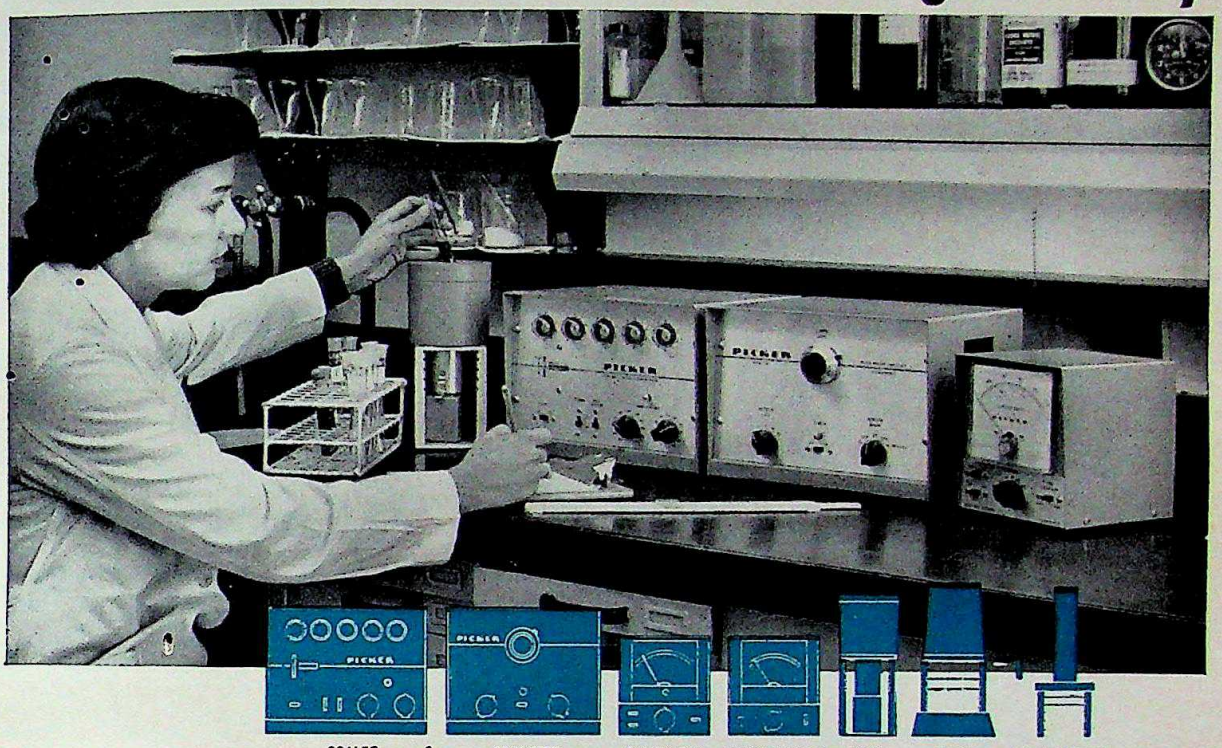

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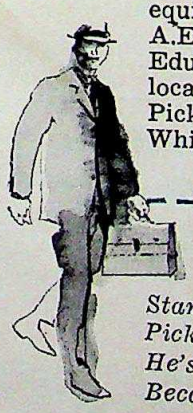

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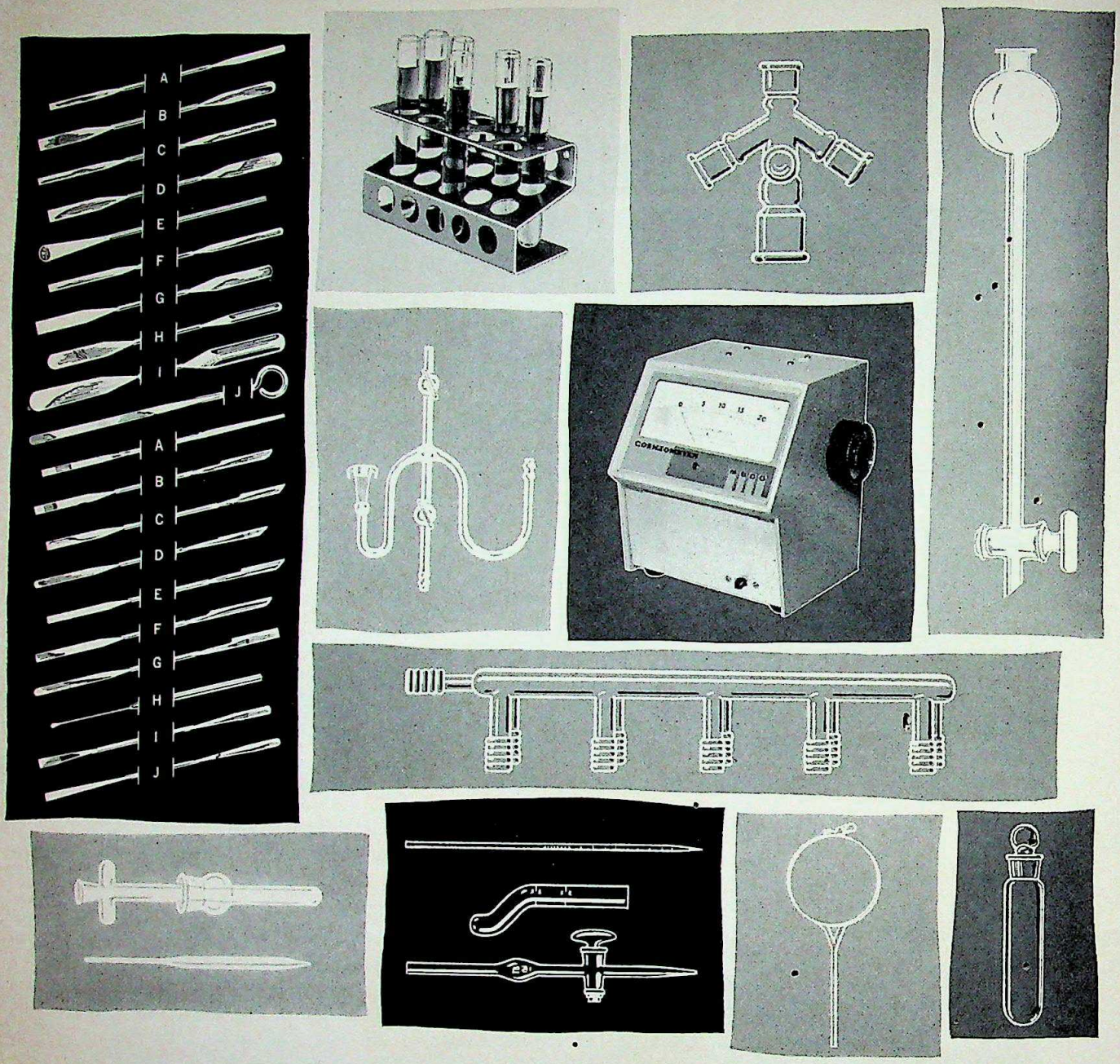

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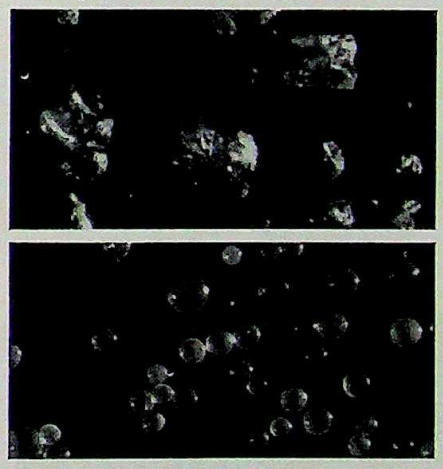

Figure 1. SEPHADEX was formerly supplied in the form of irregularly shaped particles as shown in top photograph. Now available in spherical beads as shown below, SEPHADEX facilitates packing of columns and greatly increases speed of operations.

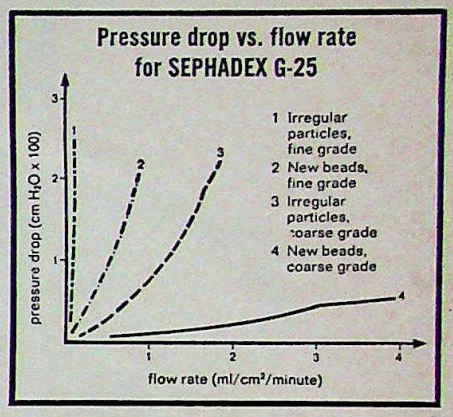

Figure 2. The curves above depict pressure-drop/flow-rate functions for columns using a 50 cm bed of SEPHADEX G-25. For given hydrostatic heads, note that the new spherical beads give up to tenfold greater effluent deliveries. Analytical procedures are hastened and preparative operations are put within economically practical engineering ranges.

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G-50	10,000	coarse fine	100-300 20-80	10
*G-75	50,000	one grade	40-120	12-15
G-100	100,000	one grade	40-120	15-20
G-200	200,000	one grade	40-120	30-40

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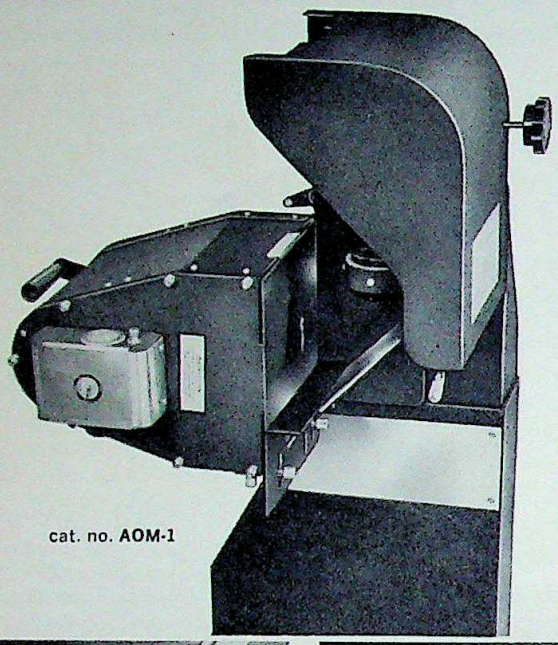

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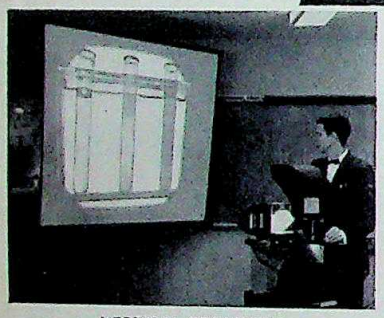

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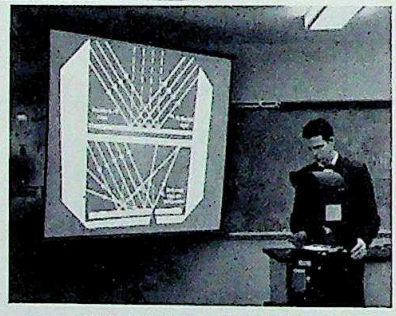

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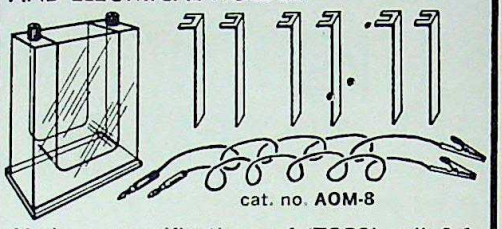

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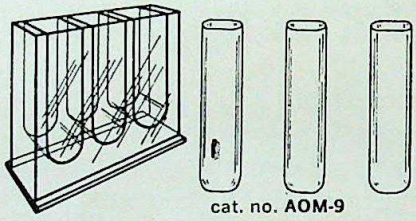

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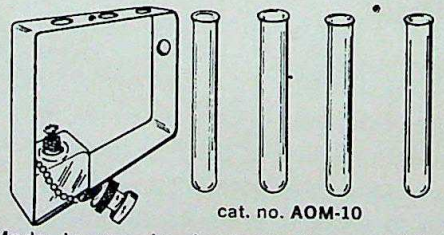

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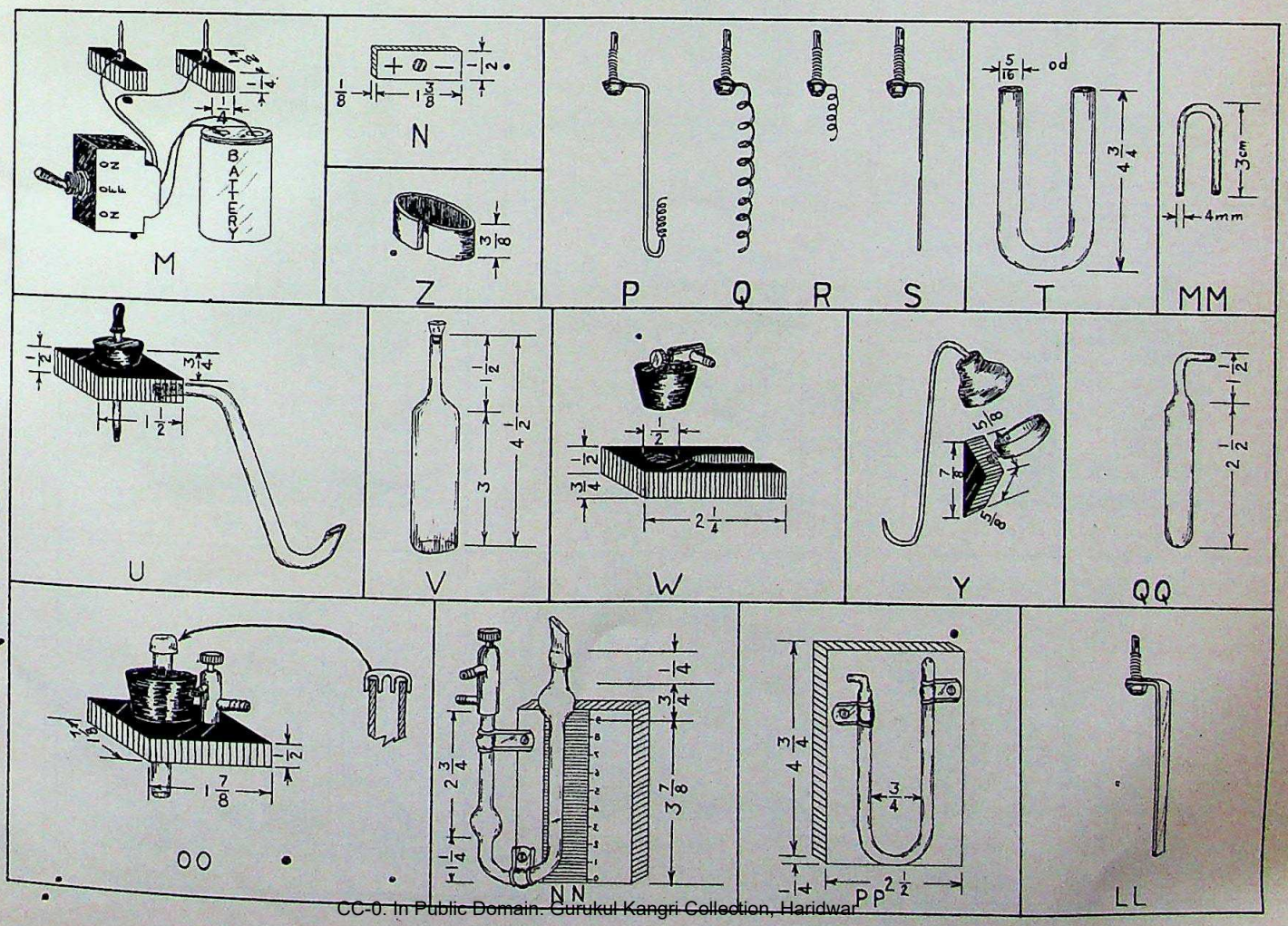
H (13 pieces) $3\frac{1}{2} \times \frac{1}{4} \times \frac{1}{2}$ in.
I (8 pieces) $5 \times 1\frac{1}{2} \times \frac{1}{4}$ in.
J (5 pieces) $5 \times \frac{3}{4} \times \frac{1}{4}$ in.
K (3 pieces) $1\frac{1}{2} \times 1\frac{1}{4} \times \frac{1}{4}$ in.
L (8 pieces) $\frac{3}{4} \times \frac{1}{2} \times \frac{1}{4}$ in.

Other Parts

M—E-1 assembly with DPDT switch, 3 position with center off
N—polarity indicator
O—batteries + charger, 9 Volt. (2×)
P—Cu-Pt spiral (2×)
Q—Cu No. 16 spiral
R—Pt No. 22 spiral (2×)
S—Cu No. 28 enameled
T—U-tube, plastic $\frac{5}{16}$-in. o.d.
U—G-1 assembly, No. 0 stopper
V—gasholders (2×)
W—G-4 assembly with fish valve
X—4-in. culture tubes cut from Pyrex brand No. 9200 (5×)
Y—H-1 assembly
Z—culture tube clips (4×)
AA—alcohol burners (4×)
BB—6-in. culture tubes (3×)
CC—single strength glass plate $5\frac{1}{4} \times 5$ in. (3×)
DD—asbestos, $5 \times 1\frac{1}{2} \times \frac{1}{2}$ in.
EE—5 ft. × $\frac{3}{4}$ in. electrical plastic tape
FF—large rubber band, $\frac{1}{4}$ in. wide
GG—coke cap
HH—Shurite Panel Meter No. 850. 0-25 milliamperes, Cat. No. 8305 Z
II—Me-amp assembly with 0-500 ohm variable resistance
JJ—Shurite Panel Meter No. 850, 0-3 volt D.C., Cat. No. 8102 Z
KK—Me-volt assembly
LL—electrodes of Zn, Al, Pb, Mg for Me-volt.
MM—salt bridge
NN—manometer, glass, with rubber connecting tube
OO—Mp box assembly
PP—Mp J—tube
QQ—Gas thermometer bulb, glass

All subsequent demonstrations in this series will be described using these simplified tops devices.

SPECIAL PARTS FOR BASIC TOPS KIT



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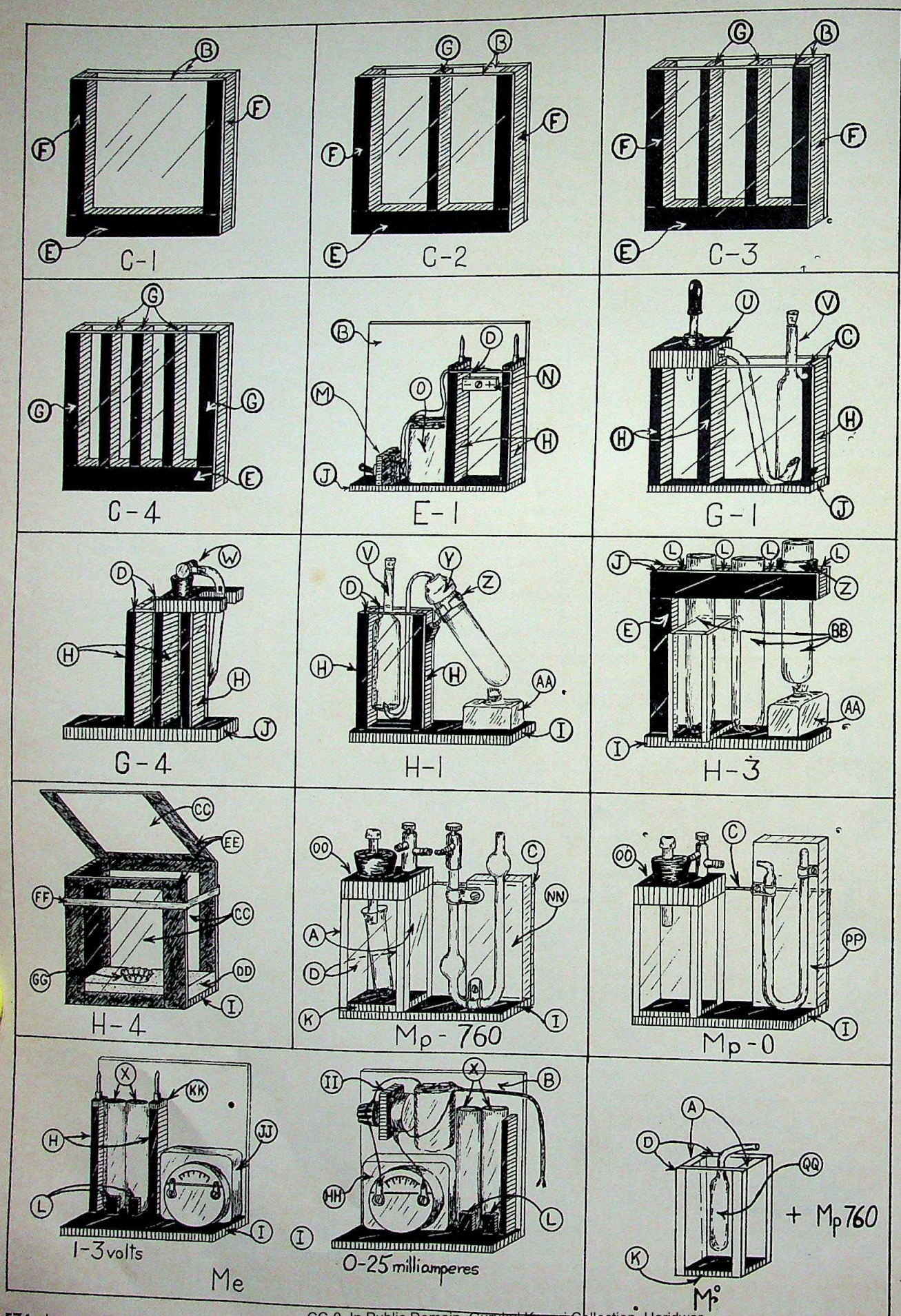

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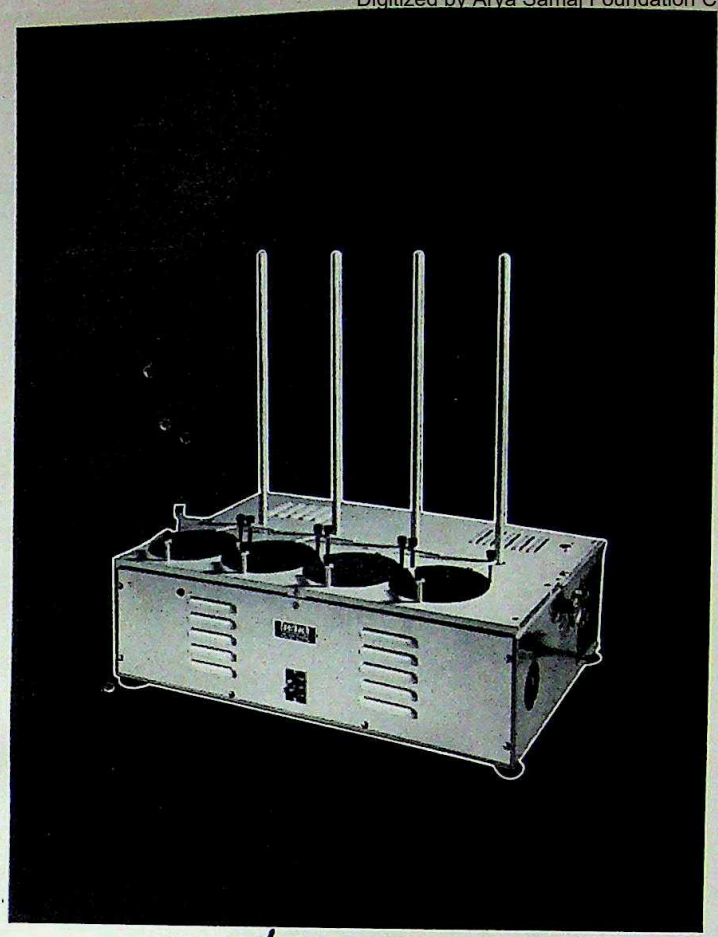

MULTIPLE-SPINDLE MAGNETIC STIRRER

Eberbach Multiple Spindle Magnetic Stirrer POWER UNIT shown here gives you 4 stirring positions for greater capacity constant speed magnetic stirring for tissue culture applications, fermentation studies and general purpose stirring. You can add 2 four position slave units and water baths in a building block concept giving a total capacity of 12 stirring positions. Variable speeds of 150 to 900 rpm. Measures 24" long, 16½" wide, 7¼" high. For 115 volt, 60 cycle AC. Catalog No. 7605 $250.00 complete with 4 vertical rods.
Request Bulletin 690

P.O. BOX 1024 **Eberbach** CORPORATION ANN ARBOR, MICHIGAN

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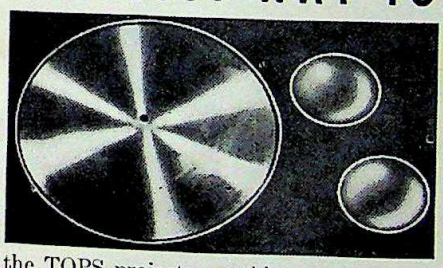


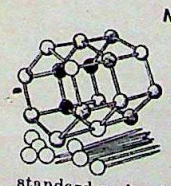
BUILD YOUR OWN TOPS PROJECTOR WITH THIS EDMUND PRECISION LENS KIT-SHOW LAB EXPERIMENTS IN ACTION

Now every teacher can have an overhead projector by following the easy-to-build plans for an inexpensive TOPS projector. It is described in the article by Dr. H. N. Alyea in the July issue of Journal of Chemical Education.

Within the budget of every teacher, the TOPS projector enables you to project an on-the-spot chemical experiment on a screen. Even a large group of students can see important phases and reactions as they occur—greatly magnified. Avoids individual experiments with possible student errors, accidents, and waste of materials.

As described and specified in the article, there are three lenses needed in the construction of the TOPS projector, available in a low-cost kit from Edmund. Kit includes: Two Plano-convex glass lenses, 86 mm. dia., 571 mm. focal length and one plastic Fresnel lens 10" dia. 8¼" focal length.
Stock No. 70,620-ET.....$9.00 Ppd.

MOLECULE KIT



The low-priced kit can be used to make many molecular and crystal models. Consists of 50 sponge rubber balls, 1 inch in diameter and 50 wooden sticks, 6" x ⅛" that can be cut to any desired length. Balls may be painted, after assembly, to standard molecular model colors. With this one kit, molecules with up to fifty atoms can be made. Several kits can be used to make up more complex models.
Stock No. 30,413-ET.....$2.50 Postpaid

CHEMICAL PREDICTOR SLIDE RULE

Dial complete chemical equations in a matter of seconds. Slide Rule actually predicts and illustrates 10,000 different chemical equations as transparent dial is rotated—also makes it easy to balance the most complex equations.
Complete with easy-to-understand instructions.
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Years in development. Precision American made. Used for checking, inspecting, small assembly work. Up to 3" working distance. Clear, sharp, erect image. Wide, 3 dimensional field. 2 sets of objectives on rotating turret. 23X and 40X. 10 Days Free Trial.
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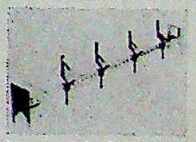
DIRECT MEASURING ATTACHMENT—with regular comparator reticle for on-the-spot checks of linear dimensions, diameters, radii and angles—in millimeters and inches.
Stock No. 40,486-ET.....$10.00 Postpaid

DIRECT MEASURING ATTACHMENT—with sand measuring reticle for sand and soil analysis.....or counting or measuring other particles of matter.
Stock No. 40,887-ET.....$10.00 Postpaid

OPTICAL BENCH



Used to test focal length of lenses: as a collimator; for projection tests of lenses (instructions furnished); many other tests of optical systems, etc. Hardwood meter stick 40" long with both inch and MM scale. 4 lens holders included to hold lenses ¼" to 3" in diameter.
Stock No. 80,064-ET.....$12.95 Postpaid

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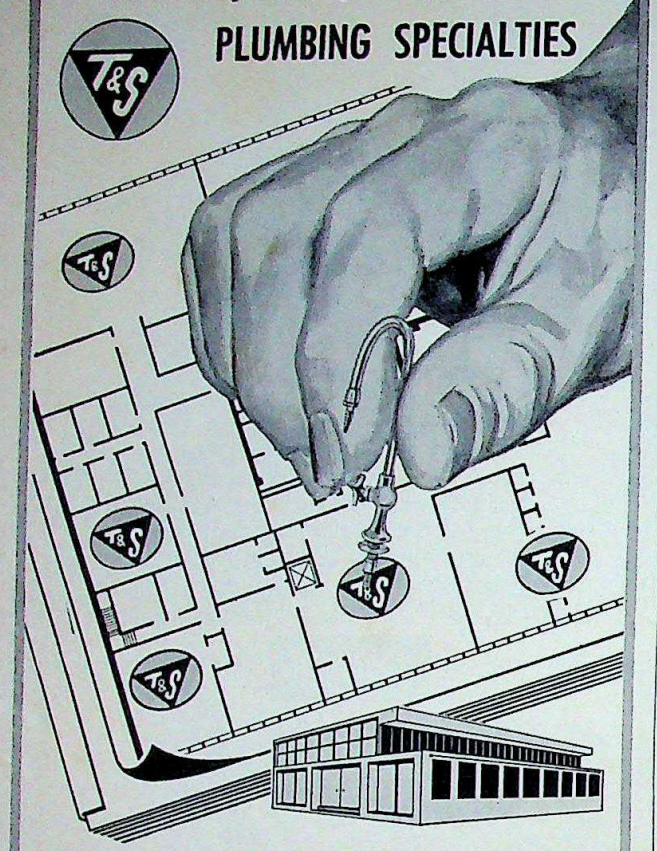

Picking the right fixture for the right spot in an industrial or institutional building plan makes the plumbing installation operate the way you designed it. T&S offers the widest range of quality plumbing specialties to choose from for every job in the building . . . and all the working tools architects and specifiers need to make plans easy, foolproof, quality controlled.

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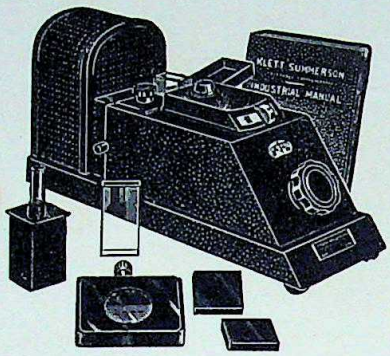
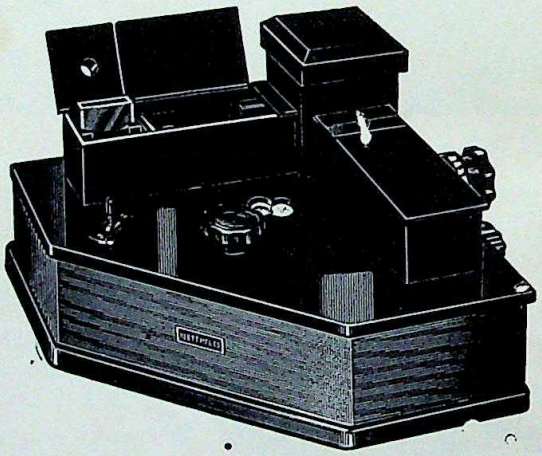
Klett Summerson



Photoelectric Glass Cell Colorimeter

No. 900-3

The Klett Fluorimeter



No. 2070

Designed for the rapid and accurate determination of thiamin, riboflavin, and other substances which fluoresce, in solution. The sensitivity and stability are such that it has been found particularly useful in determining very small amounts of these substances.

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AEROGRAPH AUTOPREP

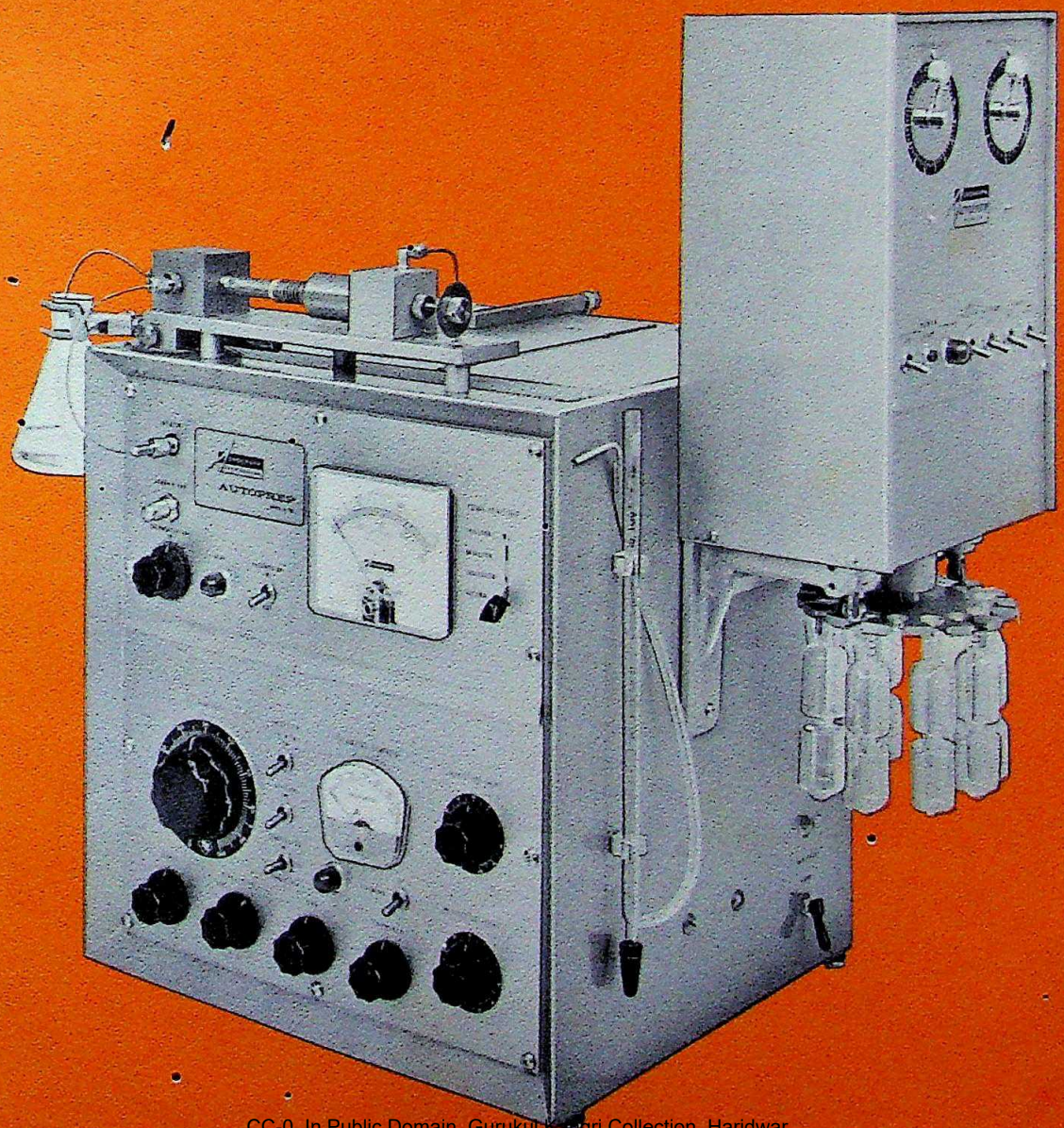
"Our Autoprep arrived last week in fine condition and is now in operation. It appears to be a little gem, and somewhat smarter than we are." This quixotic comment was recently received from one of the many satisfied chemists using the Autoprep.

The 1963 Pittsburgh Conference was the 1st Anniversary of this exceptional instrument. It is exceptional because it does so much for the chemist. It stands ready to prepare his ultra-pure fractions from mixtures which cannot be separated by distillation and saves much valuable time by doing it automatically.

During this year, users have demonstrated many examples. The latest, most amazing is the complete separation of ml quantities of ortho, meta and para xylene. As most of you know, this was a capillary job just a few months ago.

The efficiency of sample collection and types of collector bottles are shown on page 4. For more complete information write for the Autoprep Technical Bulletin and see Aerograph Research Notes, Summer 1963.

WILKENS INSTRUMENT & RESEARCH, INC. BOX 313, WALNUT CREEK, CALIF. • PHONE 415-284-7166



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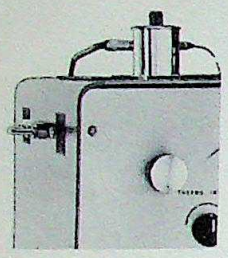
6-WAY GAS SAMPLING VALVE

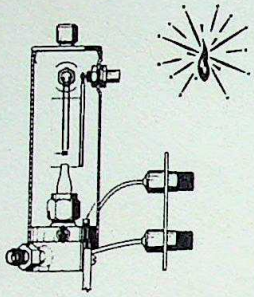
Sample reproducibility to 0.1% in gas analysis is provided by this exclusive stainless steel valve. A non-leak seal is insured by five "O" rings of silicone, neoprene, viton or Kel-F.

Price: **$ 90.00**



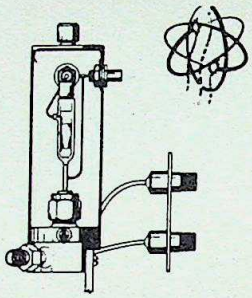
Hy-FI FLAME DETECTOR

Ultra sensitive and quantitative measurements are provided with the exclusive gold plated Hy-FI flame detector. Linear range is provided from 0.001 to 100 micrograms. This detector is quickly interchanged with the E.C. detector.



Hy-FI ELECTRON CAPTURE DETECTOR

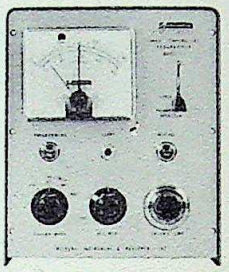
Specific sensitivity to halides, conjugated carboniles, nitriles, nitrates, organo-metals makes the unique Hy-FI concentric tube E.C. detector ideal for special analyses as DDT or lead tetraethyl. Write for Aerograph Pesticide Bulletin.



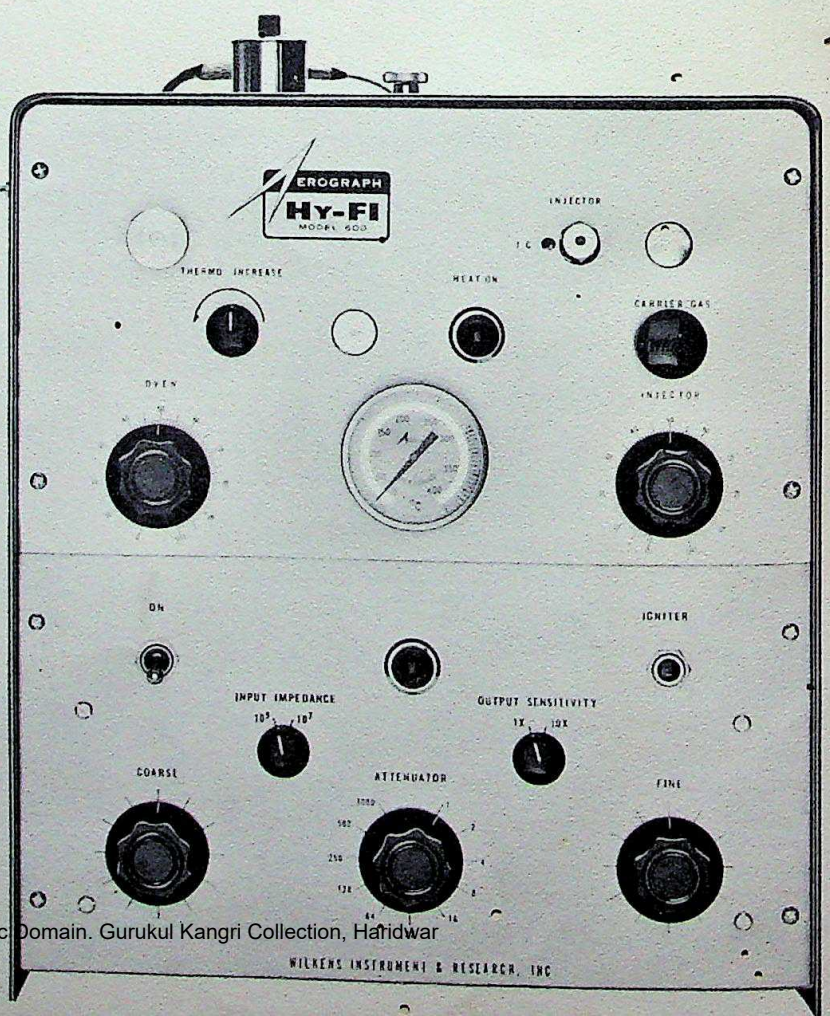
TEMPERATURE PROGRAMMER CONTROLLER

Precise linear programming or isothermal temperature control is provided with this modular unit. Its wide and accurate linear range is controlled with a platinum resistance bulb thermometer. Power consumption 50 va at 115v, 50/60 cycles; gross weight 25 lbs.; net weight 20 lbs.; size: W—8⅝", H—10¾", D—12¾".

Price: **$685.00**



HY-FI PLUS =



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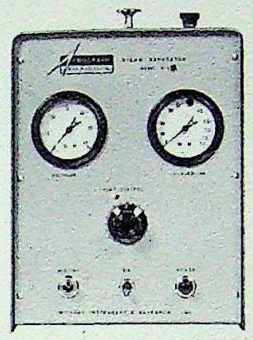
STEAM GENERATOR

Steam as a carrier gas prevents adsorption and peak tailing. This exclusive unit is an ideal companion to the Hy-FI, with gold plated flame detector. It is especially useful for quantitative analysis and for aqueous solutions. Power consumption 345 va at 115v, 50/60 cycles; gross weight 30 lbs.; net weight 25 lbs.; size: W—9", H—11½", D—13½".

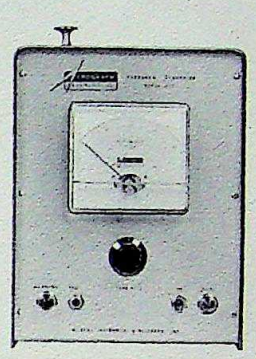
Price: **$275.00**



HYDROGEN GENERATOR

Dangerous and cumbersome cylinders, compressed air lines and special filters are eliminated with the exclusive Aerograph Hydrogen Generator. It provides both filtered hydrogen and air for the flame detector. Power consumption 50 va at 115v, 50/60 cycles; gross weight 29 lbs.; net weight 23 lbs.; size: W—9", H—11½", D—13½".

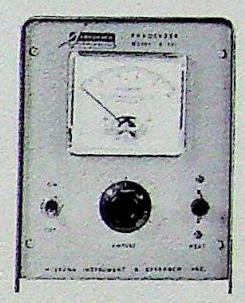
Price: **$295.00**



AEROGRAPH PYROLYZER

Non-volatile substances yield characteristic volatile fragments by thermal fission. The Hy-FI with attached Pyrolyzer is ideal for this type analysis with either flame or E.C. detector. Power consumption 75 va at 115v, 50/60 cycles; gross weight 17 lbs.; net weight 14 lbs.; size: W—6¼", H—8⅜", D—8½".

Price: **$250.00**



Hy-FI OVEN WITH TRANSFER SWITCH

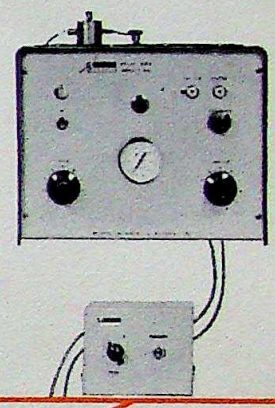
An extra oven with transfer switch, as a companion to the Hy-FI can actually provide the chemist with a second complete chromatograph if used as part of a team. This oven is identical to the standard Hy-FI oven. Power consumption 425 va at 115v, 50/60 cycles; gross weight 37 lbs.; net weight 27 lbs.; size: W—11½", H—6¼", D—12¾".

ORDER:

Aerograph Hy-FI Oven with Flame Detector.

Aerograph Hy-FI Oven with E.C. Detector.

Aerograph Model A-620 Transfer Switch.



This compact chromatograph (one sq. ft.) is fully complemented with the accessories shown.

The low mass column oven permits rapid thermal change for either manual or controlled temperature programming to 400° C. Either Flame or E.C. detectors may be interchanged in minutes. A glass column and injector insert provide a non-reactive system. Capillary columns function ideally. And, of course, the separate oven can give you another complete system.

The Hy-FI manual temperature programming gas chromatograph comes complete with sensitive electrometer and standard accessories including gas and electrical connectors. Power consumption 450 va at 115v, 50/60 cycles; gross weight 54 lbs.; net weight 44 lbs.; size: W—11½", H—13½", D—12¾".

ORDER: Aerograph Hy-FI Model A-600-B with Flame Detector: **$995.00**
Aerograph Hy-FI Model A-610-B with Electron Capture Detector: **1175.00**

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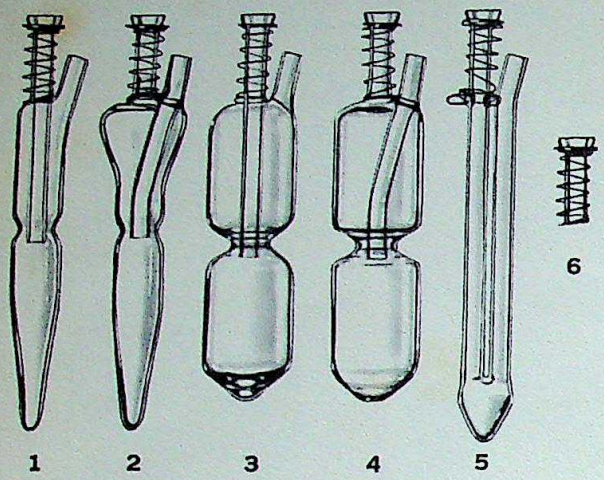
AEROGRAPH

AUTOPREP COLLECTION BOTTLES



These bottles were designed specifically for the Autoprep or for the Aerograph mechanical two-position collector. For solids, which would plug the neck of the bottle, types 2 and 4 should be used. Glass wool aerosol scrubbers are usable in any of these tubes. The bottle neck is provided for repair or for attachment to your own particular collector bottle system.

	RECOVERIES			SPECIFICATIONS	
Item	Ether %	Methyl Laurate %	Camphor %	Model	Size
1	90.2	93.0	Plugged	66-012	5 ml
2	81.0	88.5	92.7	66-018	5 ml
3	84.3	90.0	Plugged	66-011	20 ml
4	81.0	84.0	93.3	66-019	20 ml
5	91.3	96.0	Plugged	66-023	1 ml
6	—	—	—	BN (bottle neck)	

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And remember . . . the author of any item which is published in Research Notes will receive a free 10 µl w/g Hamilton Syringe. Please submit your short article (200 to 400 words) or helpful G.C. hint to Editorial Office at Walnut Creek, Calif.

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Out of the EDITOR'S BASKET

Edited by William G. Kessel

When writing for additional information about new products or for new literature, your inquiry will receive prompt attention if you write on your firm or Institution letterhead and mention the Journal of Chemical Education and the date of the particular issue. Pamphlets, booklets and similar literature are gratis unless otherwise specified.

New Apparatus and Equipment

▶ A new, more powerful, rechargeable nickel-cadmium battery, the R-400 cell, with a special truly-resealable, pressure-release vent, is available from Gulton Industries, Inc., 212 Durham Ave., Metuchen, New Jersey.

▶ Safe, rapid one-handed positioning of Dewars or other experimental containers in typical vacuum-rack applications is provided by the "vacRac," available immediately from MicroTech Services, 775 Sunshine Dr., Los Altos, California.

▶ Featuring 0.1% reproducibility and one-piece all pyrex construction, a new low cost automatic diluting machine has been introduced by Labindustries, 1740 University Ave., Berkeley, California. Simple and trouble-free, L/I's dilutor mounts directly on the customer's or Labindustries' diluent bottle, thus requiring no additional table space.

▶ Loenco, Inc., 2092 N. Lincoln Ave., Altadena, California, has developed a new process chromatographic system (Model 15B-XP) which combines high sensitivity and high flexibility. Automatically analyzes for oxygen, nitrogen, carbon monoxide, and carbon dioxide, giving either bar graph or chromatogram readout.

▶ Phoenix Precision Instrument Co., 3803–05 N. Fifth St., Philadelphia 40, Pennsylvania, announces the availability of new chromatographic columns. The new columns feature a unique bottom connector with removable porous teflon disc, thus eliminating the difficulties often encountered with permanently fused sintered glass disc type columns.

▶ Featuring compact bench-top size, including refrigeration, a new Model 2210 automatic liquid scintillation spectrometer has been announced by Vanguard Instrument Co., P.O. Box 244, LaGrange, Illinois.

▶ Scientific Industries, 220–05 97th Ave., Queens Village 29, New York offers these new power supplies:

A new 2 in 1 power supply featuring an automatic safety shut-off, and capable of delivering constant voltage or constant current from 0 to 2000 volts at 0 to 100 milliamperes.

A new constant current or constant voltage power supply, the HV-200, capable of delivering 0 to 2000 volts at 0 to 100 milliamperes and featuring an automatic safety control.

▶ A new Flowmeter Kit, Series 300, consisting of 4 rotameters and 8 floats, in a wood carrying case, is now being offered by The Matheson Company, Inc., P.O. Box 85, East Rutherford, New Jersey. The all-glass flowmeters have standard, ground tapered joints for convenient laboratory usage.

▶ Precise, front panel dialing of desired EPR sample temperatures is now available to users of Varian Associates' V-4502 EPR Spectrometer Systems, from the Instrument Division, Varian Associates, Palo Alto, California.

A new accessory also being offered by Varian is the V-4557 Variable Temperature Accessory. A closed-loop circuit, in which a platinum wire sensor and the selector dial potentiometer form one element of a bridge, is used for temperature control.

▶ A new and improved Plexiglas glove box that is completely hermetically sealed with a new rubber sealing technique has just been introduced by Greiner Scientific Corp., 22 N. Moore St., New York 13, N. Y.

(*Continued on page A584*)

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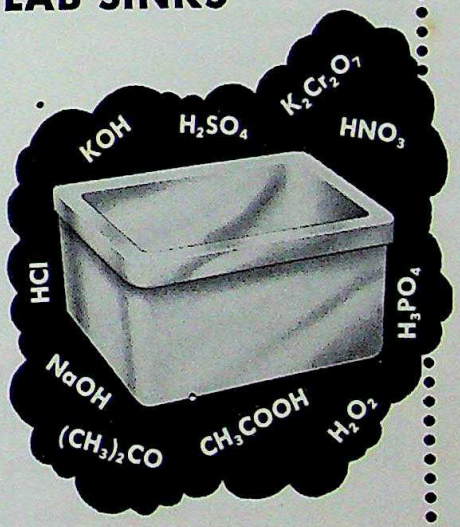

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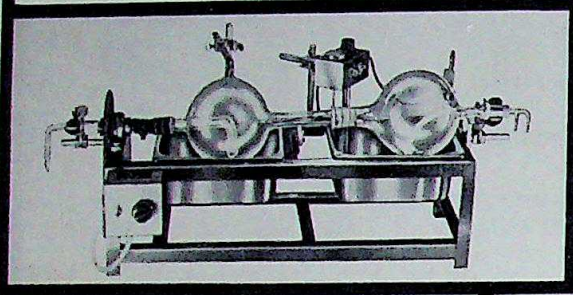

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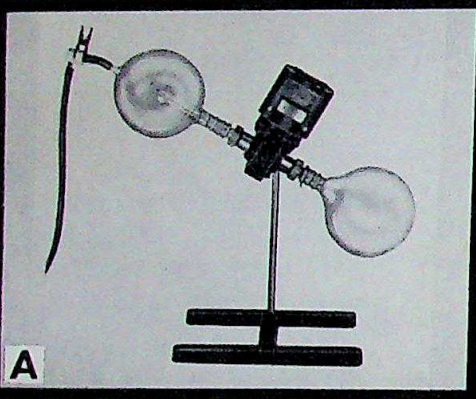

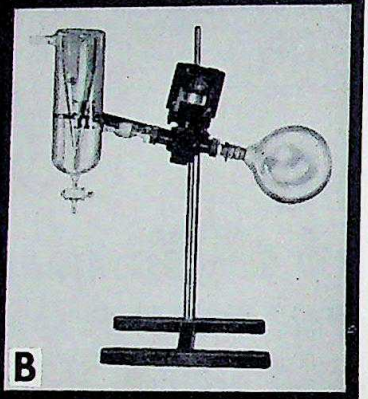

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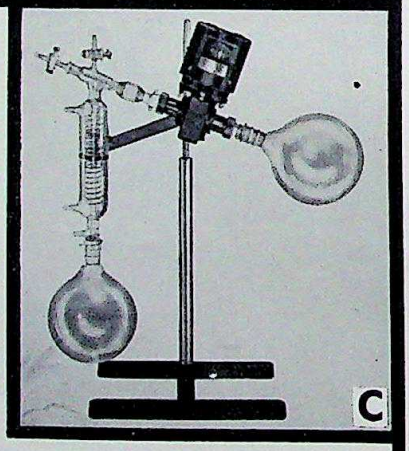

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Out of the EDITOR'S BASKET

▶ The Lourdes Instrument Corp., 656 Montauk Ave., Brooklyn 8, New York, N. Y., manufacturers of high speed and super speed centrifuges enters the low speed market with the introduction of their Model-R, completely automatic, refrigerated centrifuge with speeds up to 6000 rpm.

▶ New dual purpose Teflon cementable sleeves are offered by Ace Glass Inc., Vineland, New Jersey, as an addition to the comprehensive series of Tef-Clad joints. These new rugged Teflon sleeves are avialable in a full range of sizes for both standard taper and spherical joints.

▶ A new line of portable, self-powered electronic thermistor thermometers for field use, the 3 FOIA are now available from Atkins Technical, Inc., P.O. Box 3617 University Station, Gainesville, Florida. These new thermometers, part of an inter-related group of instruments for indicating, recording and controlling temperature, operate within a range of from −153° to +577°F or from −102° to +302°C.

▶ A radically new type of radiation dosimetry system believed to be invaluable for a wide range of nuclear, X, and space radiation research has been perfected by Controls for Radiation, Inc., 130 Alewife Brook Parkway, Cambridge 4, Mass.

▶ A new, low-cost, high-quality spectrographic laboratory instrument, the "Spectrographic Analyzer," has been announced by Applied Research Laboratories, Inc., P.O. Box 1710, Glendale 5, California.

▶ American Balance Corp., 48 Potter Ave., New Rochelle, New York offers a newly engineered single pan balance with advanced design features, the "Quik-Chex."

▶ Edcraft Industries, Inc., 22 Newbitt St., Newark 3, New Jersey, has just introduced the Model 130 "Colonial Atmosphere Enclosure," a transparent, self-contained, miniature Clean Room with its own filtered air supply.

▶ Baird-Atomic, Inc., 33 University Rd, Cambridge 38, Massachusetts, has developed an all-transistorized digital ratemeter. The University II Series Model 425 is inherently error-free, since digital circuitry is used throughout. Basically an automatically recycling scaler plus preset timer, the digital ratemeter computes counts per minute or per second and displays the computed value continuously.

▶ An introductory kit for thin-layer chromatography, available from Research Specialties Co., 200 S. Garrard Blvd., Richmond California, permits application of the TLC technique on an inexpensive trial basis to determine need for additional equipment. Minimal equipment is provided to produce and develop thin-layer

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chromatograms; and 14 different adsorbents are supplied in sufficient quantity for several trials with each.

An extensive up-to-date TLC bibliography is included (over 300 references), as well as a catalogue of the company's complete line of "Chromatofilm" equipment for TLC. The user may incorporate the kit into his expanded TLC laboratory, as its components are standard reusable items.

New Literature

● Some 160 new listings of Kimax fritted ware are described in *Catalogue Supplement SC-180* now available from Owens-Illinois, Toledo 1, Ohio.

● Detailed price schedules on electrostatic dc generators may be obtained by writing Sames USA, Inc., 269 Commercial Ave., Palisades Park, New Jersey.

● A reprint from *Safety Engineering*, "How to Put a Chill on Refrigerator Explosions" and information on current models of explosion-proof refrigerators is available from Kelmore, Inc., 599 Springfield Ave., Newark 3, New Jersey.

● *Methods* is a quarterly journal dealing with the theory and mathematics of medical research; methodology of controlled clinical trials and of etiological and epidemiological investigations; problems of nomenclature, terminology and classification; mechanical data selection; automatic data processing, and literature documentation. Subscriptions are available for $5.00 from Joseph Bourgholtzer, Inc., 179 E. Ridgewood Ave., Ridgewood, New Jersey.

● Platinum, palladium, gold, and their alloys in the form of wire, sheet, foil, tubing and miscellaneous mill products are reviewed in a new sixteen page booklet published by Baker Platinum Division of Engelhard Industries, Inc., 75 Austin St., Newark 14, New Jersey.

● Catalogue No. 5, *Pure Chemicals, for Research and Gas Chromatography* may be obtained from Lachat Chemicals, Inc., 10540 S. Western Ave., Chicago 43, Illinois.

● The 1963 edition of the *Film Guide on Chemicals, Chemistry and the Chemical Industry* is now available from the Manufacturing Chemists' Association, 1825 Connecticut Ave., N.W. Washington 9, D. C. The revised publication which lists 271 films is sub-divided into 16 categories ranging in interest from Chemistry and Agriculture, to Space.

● The June issue of the *Gas-Chrom Newsletter* (Applied Science Laboratories, Inc., State College, Pa.) features a description of chromatograph modifications for improved steroid analysis, including provisions for sample injection directly into

(*Continued on page A586*)

A Laboratory Glass Cutting Unit
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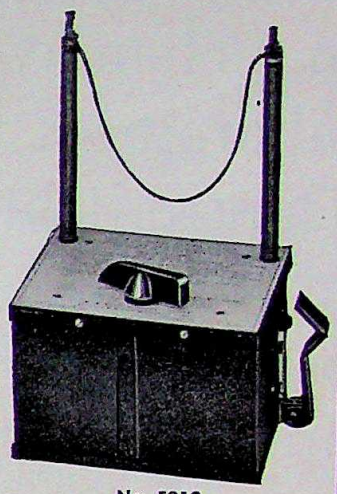

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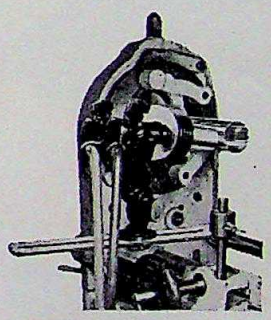

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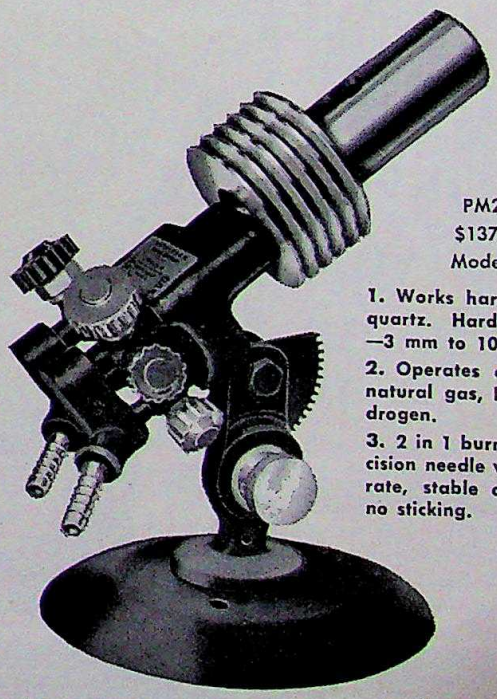

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a glass column. Details on construction are given. The same issue also includes a comparative evaluation of boron trifluoridemethanol and boron-trichloride methanol reagents for interesterification of triglycerides.

● Nucleonic Corp. of America, 196 DeGraw St., Brooklyn 31, New York offers, on request: 1. A free wall chart "Radiation Protection Guide." 2. Experiment manuals in radiobiology, radiochemistry, nuclear physics. 3. Lecture and laboratory courses in radiobiology, radiochemistry, nuclear physics and medicine. 4. A new complete catalogue of nuclear equipment and services.

● EAI Electronics Associates, Inc., Long Branch, New Jersey, have available a new brochure describing their research and computation division "to predict and control."

● New brochures on *Alicyclic Compounds* and *Organic Positive Bromine Compounds* as well as numerous data sheets on special compounds may be secured from Arapahoe Chemicals, Inc., 2855 Walnut St., Boulder, Colorado.

● A bulletin, entitled *Elementary Gas Chromatography* describes the techniques of this field, how they evolved, their applications, and a bibliography of literature on the subject. It is written as an introduction to this subject and includes a schematic of a gas chromatographic system and a typical chromatograph.

Requests for single copies in the case of students, or multiple copies in the case of teachers should be directed to Johns-Manville, Box CPOD-9, Celite Division 22 E. 40th St., New York 16, N. Y.

● Copies of *1963 Matheson Compressed Gases and Fluid Controls* can be obtained from The Matheson Co., Inc., P.O. Box 966, Joliet, Illinois.

● A new series of technical data sheets published by Servo Corp. of America, 111 New S. Rd., Hicksville, L.I., New York, covers the company's line of single-element infrared lenses, as well as its refractive and catadioptric optical systems.

● Fisher Scientific Co., 717 Forbes Ave., Pittsburgh 19, Pennsylvania, offers *Apparatus and Chemicals for Secondary School Laboratories* on request.

● *The Wide World of "Teflon"* tells the story of an unusual laboratory discovery and the complex technology required to develop it as a useful material. Published as a 20 page illustrated booklet by the DuPont Co., Public Relations Dept., Wilmington 98, Delaware, the story of "Teflon" fluorocarbon resins begins in DuPont's Jackson Laboratory in April, 1938, where a chemist investigating refrigeration gases, discovered a white, waxy

(Continued on page A588)

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References

(1) Ind. Eng. Chem. 26–653 (June, 1933)

(2) Ind. Eng. Chem. 25–1112 (Oct., 1933)

(3) National Bureau of Standards Journal of Research 12-241 (Feb. 1934, R.P. No. 649)

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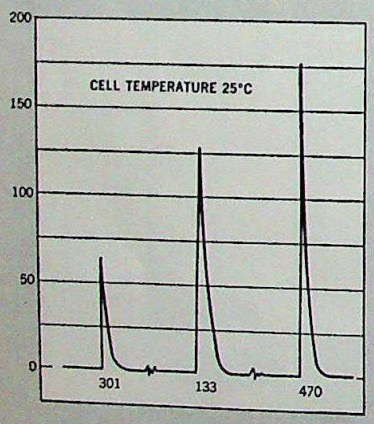

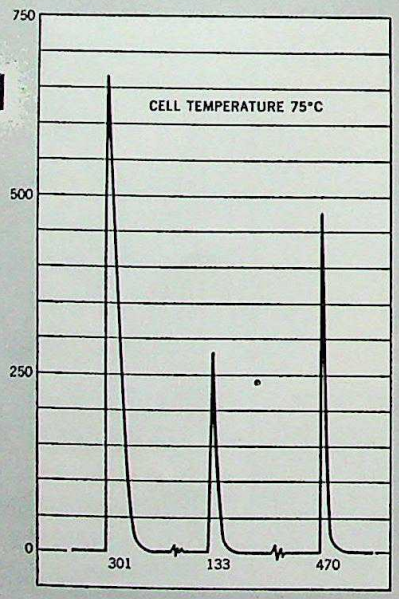

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● A 4 page brochure on a new "*Portable systems for the Chemical Laboratory is* available from the Penn-Chem Corp., 232 N. Marshall St., Lancaster, Pennsylvania.

● Write Kaman Nuclear, Garden of the Gods Rd., Colorado Springs, Colorado, for copies of *Data Sheet A-700, 701,* and *702*, describing models of neutron generators now available.

● A new 44 page catalogue is available from Keithley Instruments, Inc. 12415 Euclid Ave., Cleveland 6, Ohio, describing their full line of sensitive electronic instruments for research and industry. The catalogue is arranged into convenient sections covering measurements of dc and ac voltage, dc current, low and high resistance, dc and ac amplification, as well as sections on dc high voltage supplies, nuclear instrumentation and space science instrumentation.

● A new 8-page condensed catalogue issued by Mikros, Inc., describes the company's expanded product line of scientific instruments and components. Write Mikros, Inc., 7634 S. W. Capitol Highway, Portland, 19, Oregon.

● An illustrative, detailed brochure describing Tobor, a series of new counting systems for large volume gamma samples, is available from Nuclear-Chicago Corp., 333 E. Howard Ave., DesPlaines, Illinois. Tobor Systems introduce a completely new type of detector assembly using dual photomultiplier tubes and scintillation crystals that can be adjusted to maintain uniform geometry and efficiency for samples varying in volume and physical shape.

● A comprehensive 32-page catalogue and price list of certified tagged radiochemicals, including over 700 Carbon-14 and Tritium labeled compounds, is now available from the Radiochemical Division of Atomic Accessories, Inc., 811 W. Merrick Rd., Valley Stream, New York.

● A 16-page 1963 *Short Form Catalogue* describing the complete Houston Instrument line of X-Y recorders, T-Y recorders, and laboratory test equipment is now

(*Continued on page A590*)

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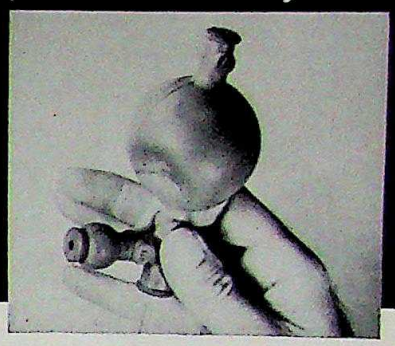

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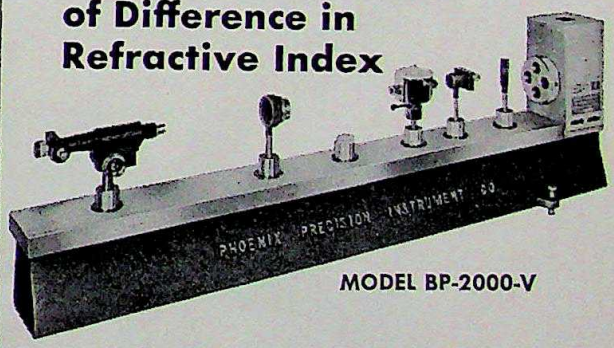

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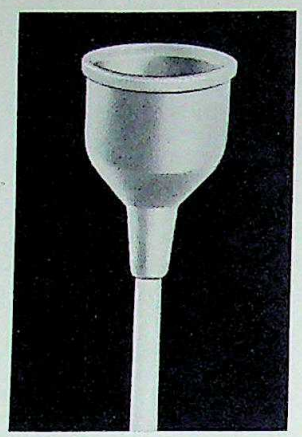

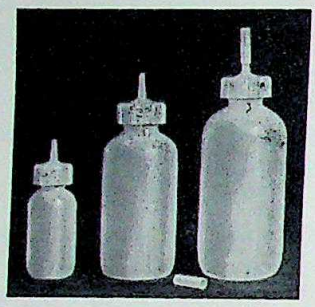

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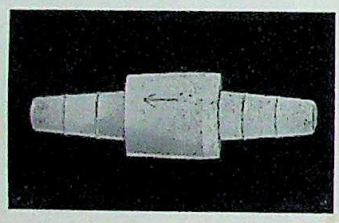

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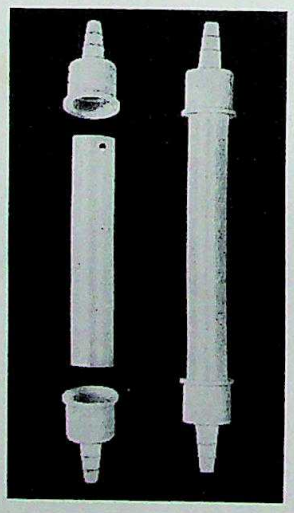

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● Reactions and uses of ethyl chloroformate, a chemical employed primarily as an intermediate in the manufacture of organic compounds, are described in a new 8-page technical bulletin published by the Organic Chemicals Division of FMC Corp., 633 Third Ave., New York 17, N. Y.

● A 2-page data sheet fully describing a versatile new compact Speedomax H Azar (Adjustable zero, adjustable range) recorder, having a zero circuit adjustable from −50 mv to +50 mv and a span circuit from 50 mv down to 800 microvolts, is available from Leeds and Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pennsylvania.

● Ohaus Scale Corp., 1050 Commerce Ave., Union, New Jersey, announces the availability of a new catalogue featuring their complete line of balances and weights.

● A new 4-page technical brochure is available from the Jarrell-Ash Co., 26 Farwell St., Newtonville, Massachusetts, regarding the firm's new Laser Microprobe, believed to be the world's first commercially marketed application of a Laser instrument.

● A comprehensive catalogue of ultra pure chemicals entitled *Space Age and Electronics Chemicals* may be obtained from Will Scientific, Inc., Box 1050, Rochester 3, New York. Catalogue includes typical analysis and impurities, prices, and in the case of the phosphors, charts of the compounds emission spectra.

● An 8-page brochure introducing the Resistal line of laboratory surface equipment has been released by Polycone Corp., 8858 W. 47th St., LaGrange, Illinois.

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● The 1963 edition *Fine Organic Chemicals for Research* is available from Frinton Laboratories, P.O. Box 301, South Vineland, New Jersey.

● *Research on Crystal Growth and Characterization at the National Bureau of Standards During the Period July to December 1962*, by H. Steffen Peiser, National Bureau of Standards Technical Note 174, issued March 15, 1963, 32 pages, 25 cents. (Order from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.)

● *A Method for Estimating The Heat of*

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Formation and Free Energy of Formation of Inorganic Compounds. E. E. Wilcox, Lawrence Radiation Laboratory, for the U. S. Atomic Energy Commission. August 1962. 120 pages. (Order UCRL 10397 from OTS, U. S. Department of Commerce, Washington 25, D. C., price 2.50.

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Miscellany

★ The National Bureau of Standards, U. S. Department of Commerce, is sponsoring a symposium on the use of the ellipsometer to measure the properties of surfaces and thin films. The symposium will be held at the Bureau's Washington, D. C., laboratories on September 5 and 6, 1963. Additional information is available from the NBS Office of Technical Information, Washington 25, D. C.

★ Four groups of metal standard samples have recently been issued by the National Bureau of Standards, U. S. Department of Commerce. Included in the new standards are four high temperature alloys and ten copper-base alloys for calibrating optical emission and X-ray spectrochemical procedures. Two new Zircaloy-2 standards primarily designed for optical emission spectro-chemical analysis has been issued for one Zircaloy-2 and two zirconium metal standards which were made available earlier. A leaded steel standard suitable for both optical emission and X-ray spectroscopic analysis has also been issued.

★ For information on how to obtain a Varactograph slide rule for use in selecting varactor diodes for harmonic multiplier circuits write *Varactograph*, Varian Associates, Salem Rd., Beverly, Massachusetts.

★ The Canisius College Department of Chemistry announces its seventh annual infrared spectroscopy institute to be held at the College from August 19–23.

This Infrared Spectroscopy Institute has been planned for three general groups of scientists: those having no background and who would like to learn the methods of interpreting spectra; those teachers and industrial workers who are experienced in the infrared spectroscopy but who would like

(*Continued on page A592*)

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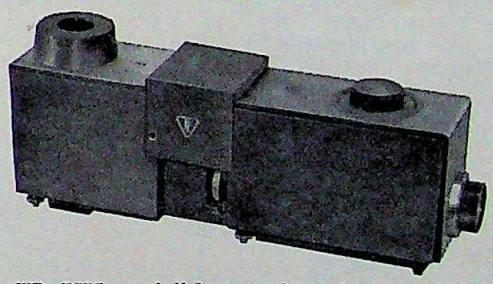

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further background; and those who wish to learn theoretical spectroscopy. Write Dr. Herman Szymanski, Chairman, Canisius College, 2001 Main St., Buffalo 8, New York for details.

★ A new, exclusive, professional method for lettering transparencies—which enables the user to add full color titles, phrases or labels to any opaque or transparent material in a matter of minutes—has been introduced by Color-Stik, 219 S. 18 St., East Orange, New Jersey. The new Color-Stik Letters are especially applicable to lettering acetate transparencies which are used with an overhead projector.

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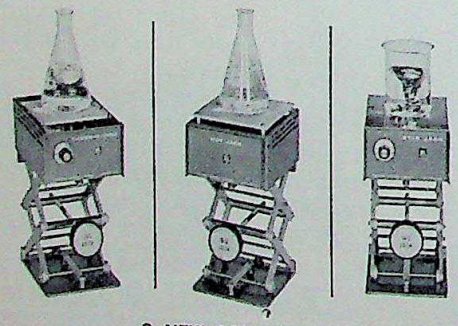

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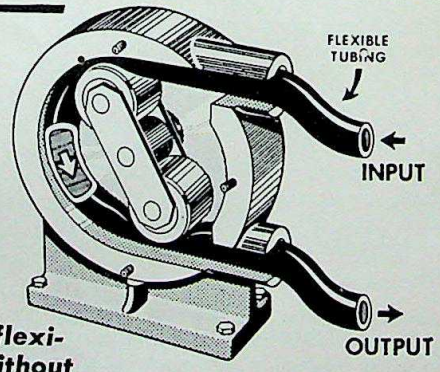

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OXIDATION OF IODINE

A Chem Ed TESTED DEMONSTRATION

Submitted by: Noojin Walker, Jr., Pensacola Junior College
Checked by: David Cohen, Education Department, Victoria, Australia

PREPARATION

Prepare 100 ml of a 0.1 *M* KI solution, and 50 ml of chlorine water for the first demonstration. For the second demonstration, prepare 100 ml of $KClO_3$ solution by dissolving 8.0 g of $KClO_3$ in 100 ml of slightly warmed water acidified with 5 ml of concentrated HNO_3. Prepare also an aqueous iodine solution by dissolving one or two small iodine crystals in 5 ml of methyl alcohol and adding 100 ml of water. Obtain two 250-ml Erlenmeyer flasks.

DEMONSTRATION

1. Pour 100 ml of KI solution into an Erlenmeyer; add chlorine water and shake. The appearance of an orange-brown solution indicates the oxidation of iodine.

$$I^- + {}^1/_2\, Cl_2 \rightarrow Cl^- + {}^1/_2\, I_2$$

2. Pour 100 ml of the acidified $KClO_3$ solution into an Erlenmeyer; add 50 ml aqueous iodine solution and shake until color disappears (1–3 min). Decolorization of the solution is indicative of the oxidation of iodine.

$$ClO_3^- + {}^1/_2\, I_2 \rightarrow IO^-_3 + {}^1/_2\, Cl_2$$

REMARKS

Students have the misconception that since halogen activity decreases with the atomic number it is impossible for iodine to liberate the elemental form of any other halogen.

Demonstration 1 shows chlorine liberating elemental iodine.

$$I^- \rightarrow {}^1/_2\, I_2 + e^- \quad -0.53\text{ v}$$
$$Cl^- \rightarrow {}^1/_2\, Cl_2 + e^- \quad -1.36\text{ v}$$

Demonstration 2 shows iodine liberating elemental chlorine.

$${}^1/_2\, I_2 + 3H_2O \rightarrow {}^1/_2\, IO_3^- + 6H^+ + 5e^- \quad -1.19\text{ v}$$
$${}^1/_2\, Cl_2 + 3H_2O \rightarrow {}^1/_2\, ClO_3^- + 6H^+ + 5e^- \quad -1.47\text{ v}$$

Using the oxidation-reduction potentials, have the students predict whether I_2 will liberate Br_2 from BrO_3^- and whether Br_2 will liberate Cl_2 from ClO_3^-.

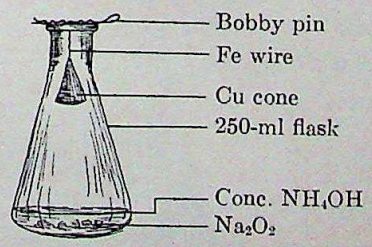
TWO CATALYSIS REACTIONS: OXIDATION OF NH_3 AND DECOMPOSITION OF Na_2O_2

A Chem Ed TESTED DEMONSTRATION

Submitted by: Peter Kauffman, 7721 33rd St. N. W., Seattle 7, Washington
Checked by: Peter Evans, Jr., Seattle, Washington and Hubert N. Alyea, Princeton University

PREPARATION

Cut a 1 in. circle of Cu foil (about 0.02 in. thick), shape it into a cone and suspend it from a bobby pin on a piece of Fe wire so that it will hang about 2 in. into a 250-ml Erlenmeyer flask. Place 60 ml conc. NH_4OH in the flask. *Slowly* add about 4 g Na_2O_2 to the ammonia while swirling constantly (take about 45 sec to do this). (Note: Some frothing occurs due to heat of solution, releasing NH_3.)



DEMONSTRATION

Heat the cone to redness in the reducing flame of a Bunsen burner or gas torch, and quickly put it into position in the flask (see figure). (Note: The cone should continue to glow.) Add 3 drops of 1*M* $CuSO_4$ while the cone is still glowing, and observe the reactions that follow.

REMARKS

Before the addition of the Cu(II) ion catalyst, the copper cone should glow slightly in the flask due to the oxidation of NH_3 with O_2 from the air.

$$4NH_3 + 3O_2 \rightarrow 2N_2\uparrow + 6H_2O\uparrow$$

The added Cu(II) ion catalyzes the decomposition of the Na_2O_2 which does not decompose in pure concentrated NH_4OH.

$$4NH_4^+ + 4OH^- + 4Na_2O_2 \xrightarrow[\text{cat}]{\text{Cu(II)}} 4NH_3 + 8Na^+ + 8OH^- + 2O_2\uparrow$$

The added O_2 from the above reaction increases the rate of oxidation of NH_3 on the surface of the Cu cone, and mild explosions with bright yellow flames occur periodically. *Caution: Keep hands and face away from mouth of flask.* As the reaction continues, bits of copper from the cone may fall into the bottom of the flask, demonstrating the intense heat of the reaction.

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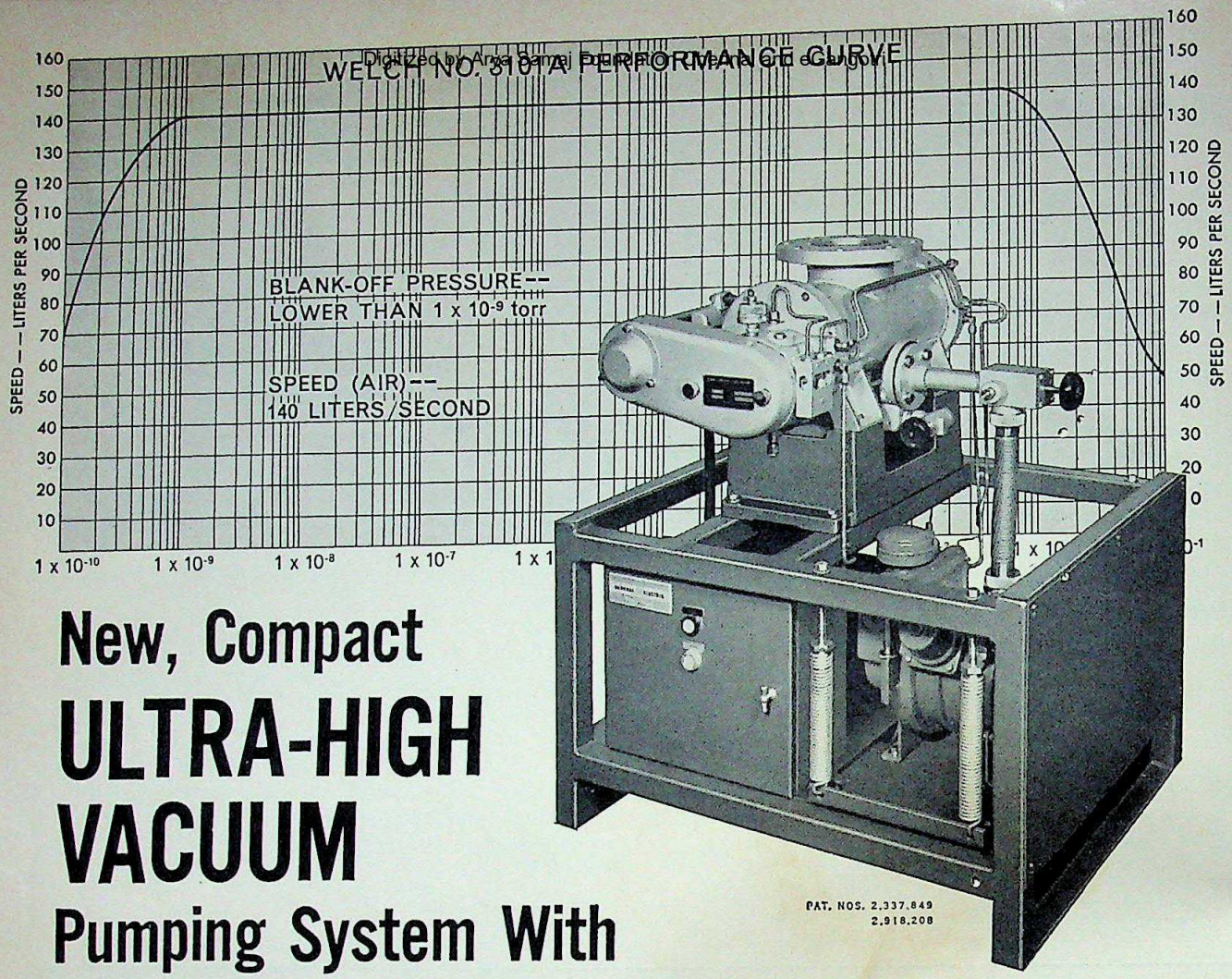

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Chem Ed

EDITORIALLY SPEAKING

A sentence in the article that begins on page 410 of this issue deserves more than a passing glance. We think it will be worth readers' time to consider more fully, "The questionnaire was designed to give a maximum of information with a minimum of effort on the part of the recipient."

There are many among our readers, we know, who feel that if all the senders of questionnaires were laid end to end that it would be a good thing. However, even among this group there will be those who sometime admit the need of a statistic, or a consensus of opinion upon which to base some realistic planning. Surveys do serve a useful function and questionnaires are a practical technique. But unless they have been properly conceived and are sensibly administered, they are a maddening waste of time.

If we make the reasonable assumption that the subject being investigated is worth the effort, how can the investigator design his questionnaire? How can he conduct his survey to overcome the natural reluctance of the already overworked recipient to engage in more "busy-work"? It is not easy. The first draft cannot be the last. Are there guidelines or principles to follow? Professor Hovey, the author of the report on page 410, has made such a list which he will send on request. We will paraphrase some of his items here.

A primary point to bear in mind is that a correspondent treated courteously will respond more fully and accurately than one who feels that the whole operation is an imposition. "Courtesy" means first-class mail, addressed by name if at all possible. Most important is to have the letter land directly on the desk of the person most likely to be properly informed and sufficiently interested to reply. A separate covering letter is better than a mere brusque preamble since it can present a rationale both for the study and the selection of the recipient. Advance thanks can be made to sound more real is accompanied by a promise to supply a copy of the results. Strict confidence and anonymity in the final report must be assured. Anonymity on the response form should be offered but usually someone who did the work of responding wants to get some credit; he should be encouraged to sign his name.

The questionnaire should be easy to complete—preferably by check-marks in ranges offered rather than by specific numbers. It goes without saying that questions must be unambiguous; a dozen clear short queries take less time than one fuzzy ill-defined cover-all question. Usually the author of the question is the last person to identify the ambiguous. A pretrial on the author's friends—or better yet, enemies—is important. Space should be provided for the recipient to express opinions if he so desires. Seldom can these be translated into numbers, but often they express the recipients' convictions, enthusiasms or abominations. Usually he feels better for having shared them.

The pre-addressed stamped envelope for return is essential. Equally essential, however, is to have this address also on the questionnaire forms; enclosures may get misplaced. Carefully, courteously worded follow-up letters in about three weeks usually transform a significant percentage of non-respondents into useful statistics.

This is sensible advice which, if followed, could make more friends and fewer enemies.

Editorial Office Change of Address

Beginning September 1, 1963 and continuing for the academic year 1963–64, the editorial office of THIS JOURNAL will be in the Department of Chemistry at MIT where the editor will be in residence as an NSF Science Faculty Fellow. All editorial correspondence should be addressed:

William F. Kieffer, Editor
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James G. Traynham
Louisiana State University
Baton Rouge

The Bromonium Ion

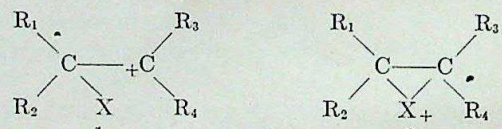
Although the concept of bridged ionic intermediates is eminently convenient and has become widespread in the interpretations of data relating to organic reaction mechanisms, it does not yet enjoy challenge-free status. Two lengthy discussions at recent national meetings[1] illustrate the active concern among organic chemists about the validity of the descriptions of some ionic intermediates at bridged or "nonclassical" ions. Largely through choice by the principal participants in these public discussions, detailed considerations were limited to some proposed ions with carbon as the bridging atom: for example, phenonium ions and ions arising from norbornane skeletons. The first bridged ion intermediate to be proposed was the bromonium ion (*1*), however, and it seems that it should receive critical evaluation at this time. Some indication of the need for such an evaluation is found in a footnote in a current text on organic mechanisms (*2*): "Although in the present chapter a number of additions are discussed in terms of the 'halogeonium-ion' mechanism, the reader should bear in mind that few organic reaction mechanisms have been accepted so widely while supported with such limited data."

Several criteria have been used in support of bridged ion concepts: rearranged products, stereochemistry, and kinetic acceleration. No one of these alone is likely to be sufficient, however. For example, while an intramolecular rearrangement (such as migration of phenyl) may require a bridged species in the course of the reaction, that species may be a transition state with (or without) classical carbonium ion intermediates on either side along the reaction coordinate. Sometimes, as in the case of cyclodecyl tosylate solvolysis, credit for an unexpectedly rapid reaction has been attributed to anchimeric assistance, without any supporting data other than the fast rate (*3a*), and subsequent study has revealed that such assistance plays little or no role in the reaction (*4*).

An entertaining and sometimes helpful analogy has been drawn between a reaction mechanism study and a murder mystery.[2] The *energetics* provide the *motive; stereochemistry*, the *alibis; kinetics*, the *eye-witness accounts;* and the *products*, the *corpse*. As in any murder mystery, the ideal mechanism investigation has available information about all of these points. But as in any murder mystery, the investigator may be forced to proceed without information on one or more of them.

Motive, for example, or the energetics, may be missing. Certainly all information on this score is helpful, but seldom do we know the important quantities, such as free energy or entropy changes, *in a way that will permit a decision* between two reasonable formulations of an intermediate. Lack of knowledge about motive, however, does not block inquiry along other lines, and the murder mystery may actually be solved without such information ever playing an important role.

The bromonium ion was first suggested by Roberts and Kimball to account for the well-established stereochemistry of bromine addition to olefins (*1*). Even this original paper indicated that the "actual structure of the ion is undoubtedly intermediate between (1) and (2)." Structure (1) was not intended to represent a conventional free carbonium ion, however: "Since



the two carbons in either structure are joined by a single bond and by a halogen bridge, free rotation is not to be expected." A clear description of the difference in binding between carbon and bromine in (1) and (2) is not given, but one infers that an electrostatic bond is implied in (1). The binding energy in the intermediate was regarded as relatively weak, weaker than the repulsive forces between the two carboxylate groups in maleate ion, which adds bromine to give the same dibromide as is obtained from fumarate ion (*1*).

Stereochemical Evidence

The bromonium ion was quickly used by other authors to account for new observations on stereospecific transformations. *Meso*-diacetate of 2,3-butanediol reacts with hydrobromic acid solution to give DL-2,3-dibromobutane, and DL-diacetate reacts to give meso-dibromide (*5*). The corresponding bromohydrins react in equivalent stereospecific manner with hydrobromic acid to form dibromides (*5*).

These results illuminate the utility of the bromonium ion concept. But stereochemistry, like alibis, may be misleading. Data from studies on deamination of amino alcohols show in a most persuasive manner that open carbonium ions can react stereospecifically (*6*).

This review was supported in part by National Science Foundation through Grant No. G14461.

[1] Symposium on Carbonium Ions, Division of Organic Chemistry, St. Louis Meeting of the American Chemical Society, March, 1961; and Conference on Reaction Mechanisms, Brookhaven National Laboratory, September, 1962. Two protagonists in each of these discussions were Professors S. Winstein and H. C. Brown, who do not always agree on the interpretation of data relating to the question of "noncalssical" carbonium ions.

[2] As a result of informal inquiry among a limited sample, our chemistry librarian (Miss May Olson) has concluded that chemists generally enjoy murder mysteries; so the analogy will be used here in discussing the bromonium ion.

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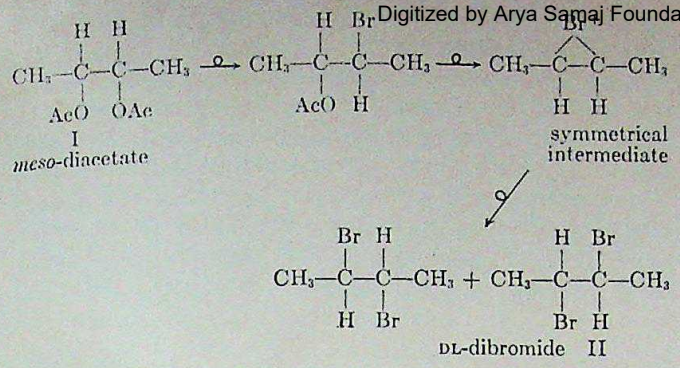
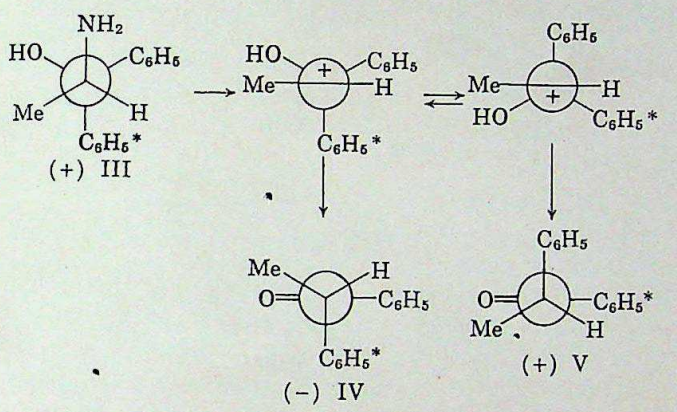
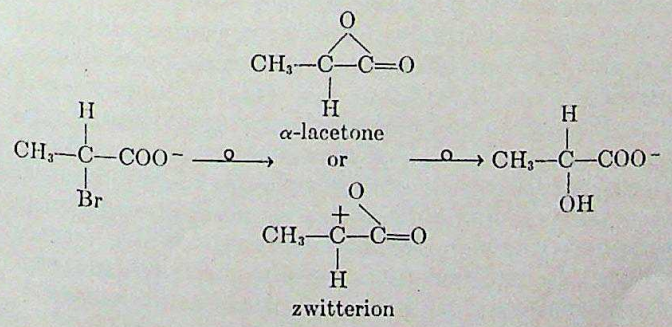


Treatment of stereospecifically-labeled (^{14}C-phenyl) amino alcohol (III) with nitrous acid led to formation of two ketones (IV and VI), each formed in a stereospecific reaction. Labeled phenyl migrated only with inversion of configuration (ketone IV); unlabeled phenyl, only with retention (ketone V). Even though the major course of reaction was to give (IV) (88%), the fact that some of the isomer was formed requires the intervention of an open carbonium ion in place of or in addition to a bridged (phenonium) ion, an open carbonium ion which retains its configuration (*6*).



An examination of the literature reveals that chemists do not always consider stereospecificity necessarily a criterion of lack of carbonium ion character in intermediates. Weakly basic hydrolysis of *alpha*-bromopropionic acid is kinetically first-order, and lactic acid is formed with retention of configuration (*7*). The intermediate has been described both as a lactone and a zwitterion (*3b*), neither of which has been prepared.

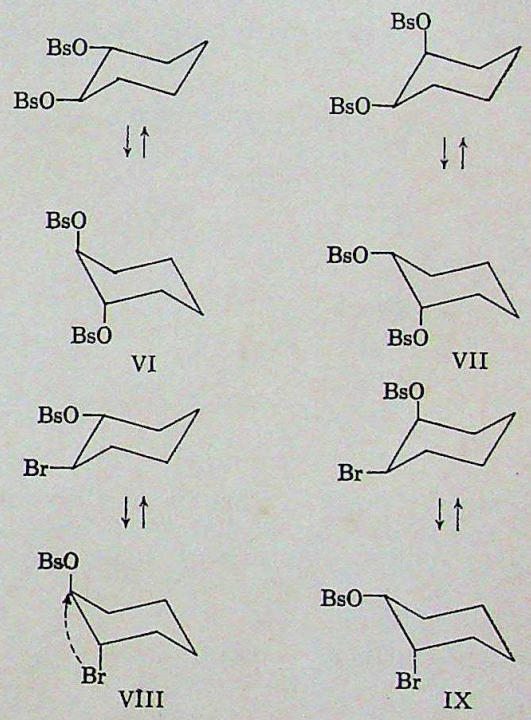


But the important aspect here is that the preservation of stereochemistry did not apparently demand a proposal of ring formation. Of course we have the many examples of S_N1 reactions, some of which apparently proceed with high stereospecificity. More or less intimate ion pairs have been postulated to account for the varying degrees of stereospecificity (*3*).

Although stereochemical data led to the original proposal of bromonium ions as intermediates, and continue to furnish some of the more convincing evidence for their existence, they fall short of being compelling.

Kinetic Data

Eyewitness accounts usually expedite the murder investigation, and kinetic investigations have provided some of the most persuasive data about the bromonium ion. The kinetic data hinge on comparisons of rates of reactions of geometric isomers, one of which is constrained to (or may assume) a conformation expecially favorable for anchimeric assistance, one of which is not. Although acetolysis of the bis-*p*-bromobenzenesulfonate (VI) of *trans*-1,2-cyclohexanediol proceeds slightly more slowly than acetolysis of the *cis* isomer (VII),[3] *trans* - 2 - bromocyclohexyl - *p* - bromobenzenesulfonate (VIII), which may assume a diaxial conformation for maximum interaction, reacts under the same conditions 810 times more rapidly than its *cis* isomer (IX) (*8*).



BsO = *p*-bromobenzenesulfonate

The relative inductive effects of a 2-(*p*-bromobenzenesulfonoxy) and a 2-bromo substituent are expected to be quite similar, and the much faster rate for (VIII) compared with (IX) is very strong evidence for anchimeric assistance (i.e., for intermediate bromonium ion formation) (*8*). The interpretation of these data is a bit more complicated than may at first appear, however. Even (IX) is solvolyzed about 5 times more rapidly than is calculated for a true carbonium ion (no bromonium ion) reaction (*8*), and *both* (VIII) and (IX) undergo acetolysis more slowly than cyclohexyl

[3] The relative rates of acetolysis of the two bis-*p*-bromobenzenesulfonates indicate that it is an axial sulfonate group which reacts. Were an equatorial sulfonate the reactive one, the *trans* ester would be favored over the *cis* ester by a statistical factor of 2. The statistical factor in diaxial conformation of the *trans* isomer and the diminished rate-retarding inductive effect (greater distance) are offset by the energy required for flipping the molecule.

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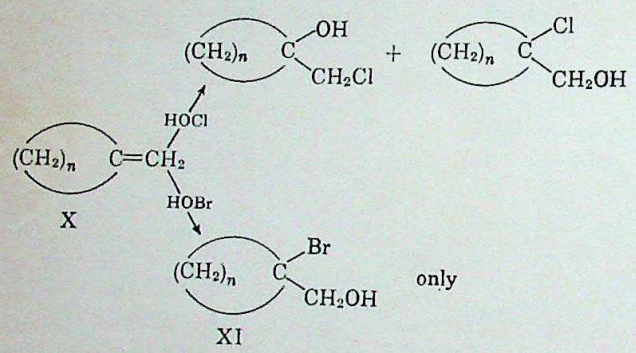
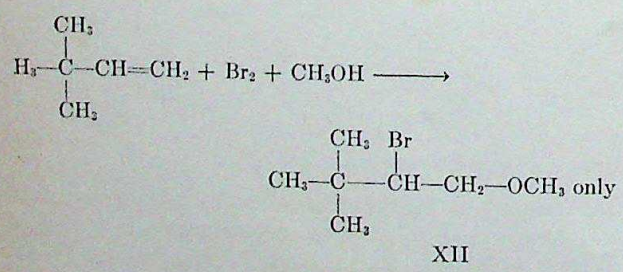
p-bromobenzenesulfonate as a result of the retarding inductive effect of the 2-bromo substituents[4] (*8*). One may be inclined to fret about the necessary balancing of expected rate retardation and expected rate acceleration, however reasonable and defensible may be the assumptions involved. Nonetheless, these eyewitness accounts of a bromonium ion intermediate cannot be easily dismissed.

The Products

The field of murder mysteries is replete with corpses which "talk." Sometimes the corpse has the most communicative role in the story. But unlike the criminal detective who must take his corpses as he finds them, the chemical detective may be able to choose his corpses in such a way as to get critical information or evidence. Some additions to selected terminal olefins lead to products which are highly suggestive. Hypochlorous acid adds to a series of methylenecycloalkanes (X), (ring sizes 4–7) to give mixtures of isomeric chlorohydrins, but hypobromous acid adds to the same olefins to give only abnormally oriented bromohydrins (XI) (*9*). In concurrent independent investigation,

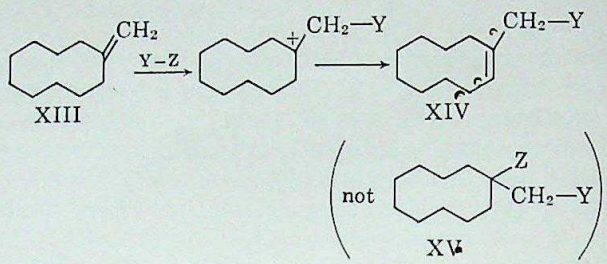


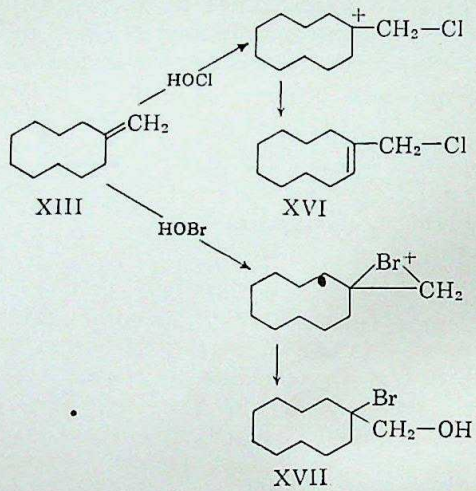
the elements of Br-OCH_3 (from bromine in methanol) were found to add to *t*-butylethylene with abnormal orientation exclusively (XII) (*10*). In both papers, the



abnormal orientation was attributed to bridged bromonium ion formation. Although the bromonium ion is a convenient representation in these cases, perhaps the most so, the case is not proved: there is no demonstration that any other plausible path would not lead to the same product. Such a demonstration has been made recently, however.

Several addends react with methylenecyclodecane (XIII) in a manner that might well be called half-addition, half-elimination (*11*). Initial attack by a cationic particle leads to an intermediate carbonium ion which then reacts to give a less-crowded olefin (XIV) rather than a more-crowded addition product (XV). Among the addends of interest here were hypochlorous and hypobromous acid. Hypochlorous acid reacts to form an unsaturated chloride, 1-chloromethylcyclodecene (XVI), exclusively; no chlorhydrin could be found. Hypobromous acid, on the other hand, leads to abnormally oriented bromohydrin (XVII) in quantitative yield (*11*). By analogy with the other attempted additions, the inference was made (*11*) that any substantial





carbonium ion character in an intermediate would lead to olefin formation, not to bromohydrin. Reduction of carbonium ion character in HOBr addition is virtually the same thing as bromonium ion formation. Because of the preferred elimination path of an intermediate carbonium ion, bromohydrin formation indicates not only that a bromonium ion intervenes but also that it is *not preceded by a conventional carbonium ion.*

Although shortcomings have been pointed out in all the previous lines of evidence, it should nonetheless be realized that these data do indeed support—and strongly—the concept of a bridged bromonium ion intermediate. The chain of evidence is compelling: stereochemistry (though inconclusive alone), kinetics (though involving a balancing of effects), and finally products (which would not be formed by an alternate route). In addition to being a most useful and convenient notation, the bromonium ion has the weight of confirmation heavily and clearly on its side.

Ladies and gentlemen of the jury: In spite of the validity of charges which have been directed at some members of the bridged ion group, guilt by association has no merit in these considerations. Therefore the motion is made for restoration of the bromonium ion as a respectable and respected intermediate in the society of organic reaction mechanisms.

[4] A *trans*-2-bromo substituent retards acetolysis of cyclohexyl *p*-bromobenzenesulfonate by a factor of 10, a *trans*-2-chloro substituent retards it by a factor of 10^4, and a *trans*-2-iodo one accelerates it by a factor of 10^3 (*8*).

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Literature Cited

(1) Roberts, I., and Kimball, G. E., *J. Am. Chem. Soc.*, **59**, 947 (1937). This may well be the most oft-cited *Note* in chemical literature.

(2) Gould, E. S., "Mechanism and Structure in Organic Chemistry," Holt, Rinehart, and Winston, Inc., New York, 1959, p. 523.

(3) (*a*) Streitwieser, A., Jr., in *Chem. Revs.*, **56**, 669, 716; and in "Solvolytic Displacement Reactions," McGraw-Hill Book Co., Inc., New York, 1962, pp. 97, 144; and (*b*) *Chem. Revs.*, **56**, 689–90; "Solvolytic Displacement," pp. 117–8 for references and comments.

(4) Prelog, V., and Borčić, S., unpublished experiments with isotopic labeling; See Prelog, V., and Traynham, J. G., in "Molecular Rearrangements," P. de Mayo, ed., Interscience Publishers, a division of John Wiley and Sons, Inc., in press, chap. 9, pp. 612–613.

(5) Winstein, S., and Lucas, H. J., *J. Am. Chem. Soc.*, **61**, 1576, 1581, 2845 (1939).

(6) Benjamin, B. M., Schaeffer, H. J., and Collins, C. J., *J. Am. Chem. Soc.*, **79**, 6160 (1957).

(7) Cowdrey, W. A., Hughes, E. D., Ingold, C. K., *J. Chem. Soc.*, **1937**, 1208.

(8) Winstein, S., Grunwald, E., and Ingraham, L. L., *J. Am. Chem. Soc.*, **70**, 821 (1948); Grunwald, E., *J. Am. Chem. Soc.*, **73**, 5458 (1951).

(9) Traynham, J. G., and Pascual, O. S., *J. Am. Chem. Soc.*, **79**, 2341 (1957); *Tetrahedron*, **7**, 165 (1959).

(10) Puterbaugh, W. H., and Newman, M. S., *J. Am. Chem. Soc.*, **79**, 3469 (1957).

(11) Traynham, J. G., and Baird, W. C., Jr., *J. Org. Chem.*, **27**, 3189 (1962).

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Demonstrating the Dynamic Behavior of Coupled Systems of Chemical Reactions

As the knowledge of chemistry advances, the chemical reactions that students must master early in their career becomes increasingly complex in their degree of interaction among the various chemical species of the system. For example, most of the reactions studied in catalytic and enzyme chemistry are sequences or parts of sequences of interdependent chemical reactions. Even the dynamic behavior of systems of first order chemical reactions containing as few as three reacting species are sufficiently complicated so that their dynamic behavior is difficult to visualize. For example, even graduate chemists often express surprise that during the course of a reaction, a given species in such a system may overshoot its equilibrium concentration for the entire system. Also, the condition for the existence of maxima or minima in the concentrations of a given species are a continuously recurring problem, as an examination of the current literature shows. New mathematical concepts are being introduced that aid greatly in the understanding of these coupled systems (see for example (*1*)); but these concepts usually lie outside the training of the student, as they often involve matrix algebra.

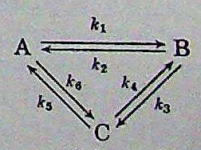
Laboratory systems are consequently needed with which the student may work in order to obtain an understanding of the dynamic behavior of coupled systems and to obtain practice in using the newer mathematical techniques. Usually the use of actual chemical reaction systems is not satisfactory, since it is difficult to find a chemical reaction which satisfies the requirements for a student type of experiment; that is, a reaction which is easy to operate, which lends itself to rapid and accurate analysis, and which does not require too much time. Furthermore, the concentration of all species at any instant of time may not be easy to obtain, in general, for an actual chemical reaction. In addition, it is desirable to have a system in which the "reaction" may be stopped at any time in order to examine more closely the state of the system; one should then be able to restart the reaction easily. The hydrodynamic system to be described offers a convenient device that fulfills these requirements.

A hydrodynamic analogue of a two component system has been described in the literature (*2*); this analogue requires pumps for a forced flow of fluid between the containers. The hydrodynamic analogue to be described in this paper depends only on a free flow of fluids between containers under the influence of gravity and is simpler to build and operate than the forced flow model. The free-flow hydrodynamic model to be described will be the analogue of an actual three-component, first order, reversible chemical reaction system. This in no way constrains the analogy since the model can be readily modified to describe other multi-component systems, other reaction orders, for both reversible and irreversible systems.

To show clearly the analogies between a chemical reaction and the hydrodynamic analogue, the two systems are first formulated mathematically; the analogies will emerge from a comparison of the systems.

The Chemical Reaction System

A typical three-component, first order, reversible, chemical reaction scheme is



Scheme I

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where A, B, and C represent the chemical species and the constants k_i are the respective rate constants.

The instantaneous rate of change of the concentration, a, of specie A is given by

$$\frac{da}{dt} = -(k_1 + k_6)a + k_2b + k_5c \qquad (1)$$

where b and c are the concentrations of the species B and C, respectively. The equation illustrates the high degree of coupling for this reaction; i.e., the rate of change of concentration a is dependent on the concentrations of every one of the species a, b, and c. This coupling is the source of difficulty in visualizing the dynamics of such systems. Similar rate expressions are obtained for the change of concentrations b and c. These rate expressions can be written as a single equation in matrix notation as follows:

$$\frac{d}{dt}\begin{pmatrix} a \\ b \\ c \end{pmatrix} = \begin{pmatrix} -(k_1 + k_6) & k_2 & k_5 \\ k_1 & -(k_2 + k_3) & k_4 \\ k_6 & k_4 & -(k_4 + k_5) \end{pmatrix}\begin{pmatrix} a \\ b \\ c \end{pmatrix} \qquad (2)$$

At equilibrium, the principle of microscopic reversibility (*3*, *4*) holds; this principle states that

$$\begin{aligned} k_1a^* &= k_2b^* \\ k_2b^* &= k_4c^* \\ k_5c^* &= k_6a^* \end{aligned} \qquad (3)$$

where a^*, b^*, and c^* are the equilibrium concentrations of a, b, and c. Thus there are only three independent rate constants for scheme I. Using equation (3) in equation (2), one obtains a matrix equation in terms of the three independent rate constants.

$$\frac{d}{dt}\begin{pmatrix} a \\ b \\ c \end{pmatrix} = \begin{pmatrix} \frac{-(k_2b^* + k_6a^*)}{a^*} & \frac{k_2b^*}{b^*} & \frac{k_6a^*}{c^*} \\ \frac{k_2b^*}{a^*} & \frac{-(k_2b^* + k_4c^*)}{b^*} & \frac{k_4c^*}{c^*} \\ \frac{k_6a^*}{a^*} & \frac{k_4c^*}{b^*} & \frac{-(k_4c^* + k_6a^*)}{c^*} \end{pmatrix}\begin{pmatrix} a \\ b \\ c \end{pmatrix} \qquad (4)$$

The compositions observed at any instant of time appear as a column matrix on each side of equation (2). This column matrix may be considered to be a vector, $\underline{a}$, with elements a, b, and c. The domain of values that the vector $\underline{a}$ may assume constitutes the composition space. Wei and Prater (*1*) have shown that studies of the composition sequences in composition space, without regard to the time variable, give all information about the system to within a mutiplicative constant; that is, one obtains the relative values of the rate constants. Such studies are easier to make than time studies and should be used whenever possible. The hydrodynamic analogue is particularly well suited for the determination of composition sequences. After the values of the relative rate constants have been obtained, a single experiment involving time is sufficient to give the multiplicative constant required to obtain the absolute values of the rate constants.

The free-flow hydrodynamic analogue of the three component chemical reaction given by scheme I is shown in Figure 1.

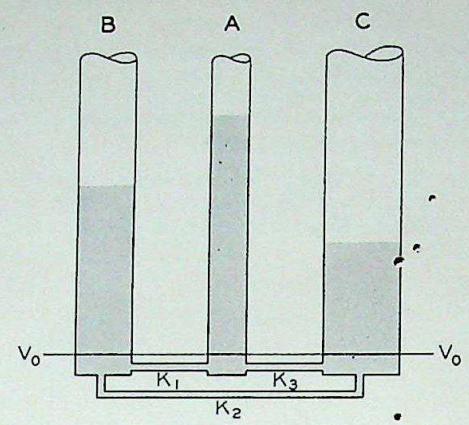

Figure 1. Hydrodynamic model of a three component, first order, reversible chemical reaction system.

The cylindrical tubes A, B, and C are of different cross sections and are connected together with different size capillaries. The rate of volume change of fluid from one tube into another through sufficiently long capillary connections is governed by Poiseuilles law,

$$\frac{\Delta v}{\Delta t} = \frac{\pi r^4}{8zL}\Delta P \qquad (5)$$

where:

$\Delta v/\Delta t$ is the rate of change of fluid volume
r is the radius of the capillary connection
L is the length of the capillary connection
z is the viscosity of the fluid
ΔP is the pressure difference across the capillary connecting the two tubes

For this system the pressure difference ΔP between any two tubes is proportional to the difference in height Δh of the two tubes. Thus equation (5) can be rewritten as:

$$\frac{\Delta v}{\Delta t} = K\Delta h \qquad (6)$$

Hence, the instantaneous rate of change is given by

$$\frac{dv}{dt} = K(h_i - h_j) \qquad (7)$$

where h_i and h_j are the heights of fluid in the ith and j^{th} cylinder respectively.

Let V_A, V_B, and V_C be the volumes of fluid in the cylinders A, B, and C, respectively, as measured from an arbitrary base line V_0. Let K_1, K_2, and K_3 be the constants of equation (7) for the respective connecting links of the cylinders of Figure 1. The rate of change of volume in tube A is then given by

$$\frac{dV_A}{dt} = -K_1(h_A - h_B) - K_3(h_A - h_C) \qquad (8)$$

where h_A, h_B, h_C are the heights of fluid in the cylinders A, B, and C as measured from the base line V_0. The negative sign in the coefficients indicate that the volume in tube A is decreasing. It is interesting to note that even though the flow in each capillary is in one direction, the mathematical formulation of equation (8)

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suggests a dynamic mechanism with forward and backward rates. Since

$$h_A = \frac{V_A}{S_A}\ ;\ h_B = \frac{V_B}{S_B}\ ;\ h_C = \frac{V_C}{S_C}$$

where S_A, S_B, and S_C are the respective cross section areas of tubes A, B, and C, equation (8) becomes

$$\frac{dV_A}{dt} = -K_1\left(\frac{V_A}{S_A} - \frac{V_B}{S_B}\right) - K_3\left(\frac{V_A}{S_A} - \frac{V_C}{S_C}\right)$$

The above equation can be rearranged to give

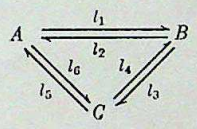
$$\frac{dV_A}{dt} = -\left(\frac{K_1}{S_A} + \frac{K_3}{S_A}\right)V_A + \frac{K_1}{S_B}V_B + \frac{K_3}{S_C}V_C \qquad (9)$$

This last equation shows that the rate of change of volume in tube A is dependent on the volumes in every tube and shows the same type of highly coupled linear rate equations as the chemical system displayed.

Similar rate expressions are obtained for the change of volume of fluid in containers B and C. Again, the three rate expressions can be written as a single equation in the matrix notation as follows:

$$\frac{d}{dt}\begin{pmatrix} V_A \\ V_B \\ V_C \end{pmatrix} = \begin{pmatrix} \frac{-(K_1+K_3)}{S_A} & \frac{K_1}{S_B} & \frac{K_3}{S_C} \\ \frac{K_1}{S_A} & \frac{-(K_1+K_2)}{S_B} & \frac{K_2}{S_C} \\ \frac{K_2}{S_A} & \frac{K_2}{S_B} & \frac{-(K_2+K_3)}{S_C} \end{pmatrix}\begin{pmatrix} V_A \\ V_B \\ V_C \end{pmatrix} \qquad (10)$$

This rate expression corresponds to the hydrodynamic flow scheme II,

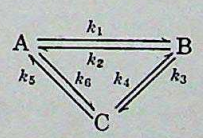


Scheme II

where A, B, and C represent the species of the three tubes and the constants, l_i, are equivalent to the respective flow constants K_i, as shown by the following column matrix.

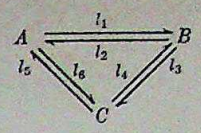
$$\begin{pmatrix} l_1 \\ l_2 \\ l_3 \\ l_4 \\ l_5 \\ l_6 \end{pmatrix} \leftrightarrow \begin{pmatrix} K_1/S_A \\ K_1/S_B \\ K_2/S_B \\ K_2/S_C \\ K_3/S_C \\ K_3/S_A \end{pmatrix} \qquad (11)$$

The analogy between the chemical reaction system and the hydrodynamic system can now be seen by comparison of scheme I of the chemical system and its rate expression with that of scheme II of the hydrodynamic system and its rate expression.



Chemical Reaction
Scheme I

$$\frac{d}{dt}\begin{pmatrix} a \\ b \\ c \end{pmatrix} = \begin{pmatrix} -(k_1+k_6) & k_2 & k_5 \\ k_1 & -(k_2+k_3) & k_4 \\ k_6 & k_3 & -(k_4+k_5) \end{pmatrix}\begin{pmatrix} a \\ b \\ c \end{pmatrix}$$



Hydrodynamic Model
Scheme II

$$\frac{d}{dt}\begin{pmatrix} V_A \\ V_B \\ V_C \end{pmatrix} = \begin{pmatrix} -(l_1+l_6) & l_2 & l_5 \\ l_1 & -(l_2+l_3) & l_4 \\ l_6 & l_3 & -(l_4+l_5) \end{pmatrix}\begin{pmatrix} V_A \\ V_B \\ V_C \end{pmatrix}$$

The Analogies Between the Two Systems

The chemical species A, B, and C correspond to the hydrodynamic species in columns A, B, and C.

The chemical concentrations a, b, and c correspond to the volumes of liquid fluid in the respective tubes V_A, V_B and V_C.

The cross-sectional areas of the tubes in the hydrodynamic model correspond to the thermodynamic equilibrium concentrations of the respective species in the chemical system. This is readily shown as follows Let a^*, b^*, and c^* be the thermodynamic equilibrium concentrations of the three chemical species and V_A^*, V_B^*, and V_C^* be the equilibrium volumes of their hydrodynamic analogues. It follows from the second analogy that a^*, b^*, and c^* correspond to V_A^*, V_B^*, and V_C^*. Now the values V_A, V_B, and V_C are equal to the heights of fluid in the tubes times their respective cross-sectional areas. But at equilibrium the heights in all the tubes are the same; hence the chemical equilibrium concentrations correspond to the cross-sectional areas of their respective hydrodynamic analogues.

The rate constants of the chemical system k_1, k_2, k_3, k_4, k_5, and k_6 are analogous to the flow constants in the hydrodynamic analogue l_1, l_2, l_3, l_4, l_5, and l_6 respectively.

In a closed chemical system, the conservation of mass states that the total mass in the system is constant during the chemical reaction. In the hydrodynamic model the conservation of mass corresponds to the conservation of the fluid volume. For the first order systems, one can use mole fractions instead of concentrations and relative volumes instead of actual fluid volumes; then the conservation laws are

$$a + b + c = 1 \qquad (a) \qquad (12)$$
$$V_A + V_B + V_C = 1 \qquad (b)$$

At equilibrium in the chemical system, the rates of change of the concentrations of the various species are zero, and the net exchange between the species is given by the principle of microscopic reversibility. In the hydrodynamic model the corresponding state occurs when the rate of change of the volume of fluid in the respective tubes is zero and there is no net exchange between each pair of tubes, i.e., when the heights of the fluids in all the tubes are the same.

The chemical potential is often thought of as the proper driving force in a chemical reaction system. There is a serious drawback in using the chemical potential as the driving force since the reaction rate is not proportional to it (except for a neighborhood of the equilibrium where the chemical potential is approxi-

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mately a/a^*). The function a/a^* is actually a better driving force (*6*).

The chemical potential of an ideal gas at a constant temperature is given by

$$\mu_i = RT \ln a_i \tag{13}$$

For the hydrodynamic model this is analogous to the function

$$\mu_i = RT \ln V_i \tag{14}$$

One could indeed use this inconvenient function as the driving force. Nevertheless, both intuition and experimental evidence point to the height h_i as the proper driving force in hydrodynamics, and by analogy one might suspect that a/a^* is the proper driving force for a first order chemical reaction. This supposition is true as has been shown by Wei (*5*) and Wei and Prater (*1*).

The Apparatus

The physical form of an apparatus based on the hydrodynamic model is shown in Figure 2. The cylindrical tubes *A*, *B*, and *C* represent the corresponding chemical species A, B, and C. A glass capillary *CP* is positioned between each pair of cylinders with rubber tubing. They can be easily removed and changed for other size capillaries. The sizes of the capillaries and the cross-sectional areas of the cylinders have been chosen to simulate closely the dynamic behavior of the composition sequences of an actual chemical reaction system observed in the laboratory; this chemical system is the isomerization of butenes over pure alumina catalyst at 230°C. The species A, B, and C of scheme I correspond to 1-butene, *cis*-2-butene, and *trans*-2-butene, respectively. The cylindrical tubes shown in Figure 2 are made of pyrex glass with cross-sectional areas proportional to the ratios of the equilibrium concentrations of the respective species. The equilibrium values for the butene isomerization system and for the hydrodynamic analogue are given in Table 1.

Table 1. Equilibrium Values

	1-butene (tube *A*)	*Cis*-2-butene (tube *B*)	*Trans*-2-butene (tube *C*)
Chemical equil. at 230°C	0.1436	0.3213	0.5351
Hydrodynamic equil.	0.1428	0.3267	0.5305

The height of fluid in each tube is measured from an arbitrary base level. For the particular apparatus described, this base level was chosen to be at the top of the nylon housing *H*. The hydrodynamic equilibrium levels are indicated by a strip of black tape at *E*. The dimensions of the tubes *A*, *B*, and *C* are given in Table 2.

Table 2. Tube Dimensions

Tube	*A*	*B*	*C*
Radius (cm)	0.96	1.45	1.85
Height (cm) corresponding to 100% of the specie	69.10	30.20	18.60
Total height (cm) of tube	77	37	25

The flow of fluid between the tubes is started or stopped by the solenoid valves *S*. Each solenoid can be activated singly or simultaneously. A drain *D* allows for easy drainage of the fluid at the end of the "reaction." The fluid used is distilled water to which has been added three drops of an ammonia-type detergent per gallon of water. This gives sufficient cleansing property to the water so that the glass walls will remain clean. At the same time this amount of detergent does not give too great a tendency to form a foam. Any stubborn dirt is removed from the glass walls by scrubbing with a brush, using the demonstrating water as the solvent.

A novel lighting arrangement provides for demonstrations to large audiences. A light shines through the bottom of the individual tubes, travels through the water and illuminates the water meniscus. Since clear water is used, the light appears to come for the most part from the meniscus. This lighting technique has the advantage that one can easily determine at a glance the height of water in the tubes. Since the height of water is proportional to the concentration of the individual species concentration changes are readily seen. To further facilitate

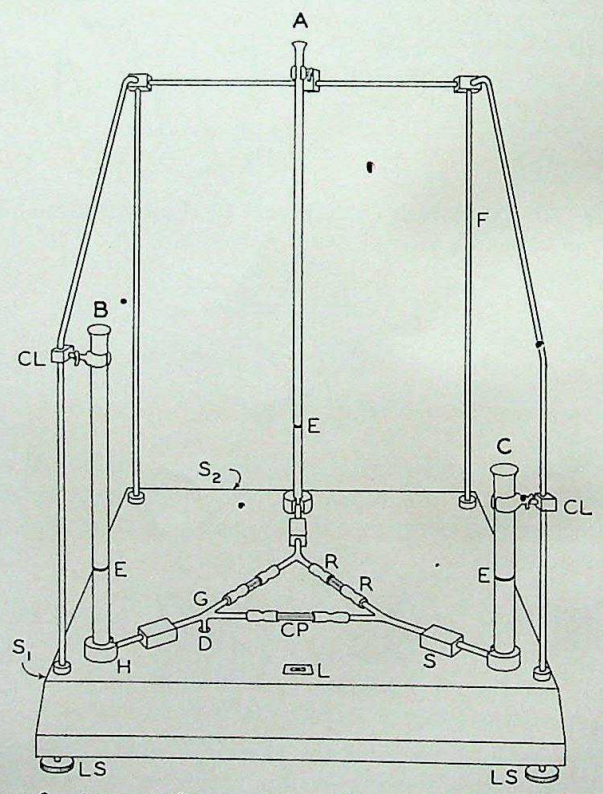

Figure 2. Apparatus for demonstrating the action of a three-component, first-order, reversible chemical reaction system.

- *A* Glass tube representing 1-butene
- *B* " " " *cis*-2-butene
- *C* " " " *trans*-2-butene
- *CP* Capillary tubes representing rate constant ratios
- *CL* Clamps
- *D* Water drain after reaction completed
- *E* Equilibrium level marker
- *F* Frame, made of aluminum rods with sheet aluminum table
- *G* Glass tubing connections
- *H* Holder—holds glass tubes in position—also contains light and colored filters
- *L* Level bubble
- *LS* Leveling legs
- *R* Rubber tubing connections
- *S* Solenoid housing
- S_1 Side panel #1—contains light switch, solenoid switches, drain line
- S_2 Side panel #2—contains 115 volt ac connection

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the visual demonstration, the lights pass through different colored filters, so that each individual meniscus is of a different color.

The Operation and Use of the Hydrodynamic Apparatus

A picture of the apparatus is shown in Figure 3. In order to indicate the operational procedures for using the apparatus, a typical reaction will be described. Some uses of the apparatus in illustrating phenomena present in chemical reactions will then be discussed.

The reaction to be described is for a initial charge of 100%, 0%, and 0% for the specie A, B, and C respectively. Tubes *B* and *C* are filled to their zero concentration levels and tube *A* at the 100% level. All the solenoids are then activated simultaneously allowing the water to flow into the other tubes. After a time interval, the reaction is stopped with the solenoid switch. The concentrations are analyzed in terms of the volume of water in the tubes. (Since the tubes are cylinders, the volumes will be proportional to the heights of water in the tubes and the heights of the tubes can be calibrated in terms of concentrations.) The solenoids are again activated for a few seconds and the system analyzed for the new set of concentration values. In this manner one obtains a record of the sequence of concentration values from a particular starting composition to equilibrium. The equilibrium height, which is the same for all the cylinders, is marked by a black strip of tape.

Some of the phenomena that can be illustrated with the apparatus are:

Overshooting of Thermodynamic Equilibrium. The height of water in the tubes shown in Figure 3 shows a particular set of concentration values for the reaction just described. It illustrates an important characteristic of complex reactions; in the course of a reaction one of the species may overshoot its equilibrium concentration. By this is meant that the concentration of the species will go from a value less than to a value greater than its thermodynamic equilibrium concentration during a reaction. Of course as the reaction continues, this species will approach its equilibrium value. In the example given the species which has overshot its equilibrium is the species B. The picture was taken when the concentration of this species was at its maximum. The amount of overshoot can be changed by using different size capillaries. This leads to another important phenomenon that the apparatus illustrates.

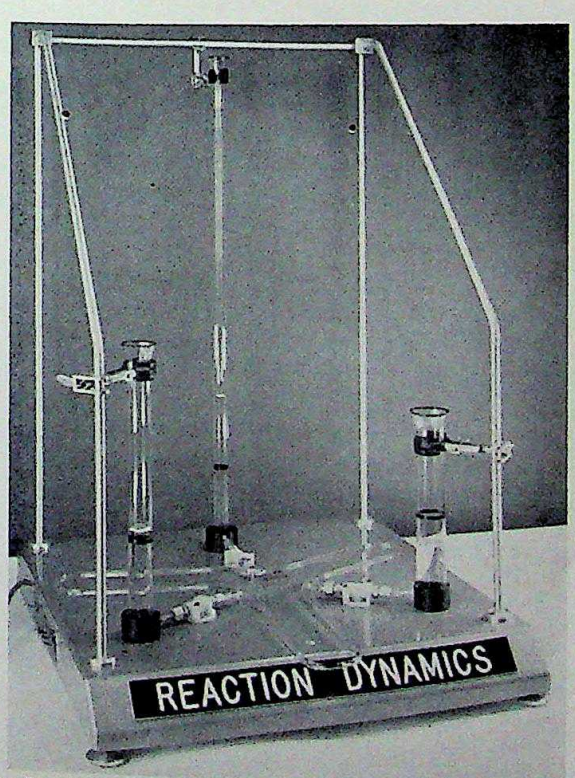

Figure 3. Photograph of the hydrodynamic apparatus that simulates a three component first order, reversible chemical reaction.

The Role of Catalyst in a Reaction. Different catalysts effect a reaction by their different rate constant ratios. Since the rate constant ratios correspond to the capillary sizes, changing these capillaries has the effect of changing the catalyst in the reaction. The effects of different capillary sizes on a reaction, particularly in maximizing or minimizing a certain species, can be investigated. The problem of determining the conditions for maximum or minimum in the concentration of a given species is an important one in science and industry. Another important observation the student can make is that no matter what size capillaries are used, the water will eventually reach the same equilibrium height. For the chemical system, this corresponds to the fact that, as long as the equilibrium composition remains fixed, the values of the individual rate constants cannot be changed in an arbitrary manner; only the ratios of the constants for each step can be changed. This demonstrates one of the consequences of the principle of microscopic reversibility.

Irreversible Reactions. Irreversible reactions and their effect on the over-all chemical reaction can be demonstrated by continuously draining off portions of the fluid at the appropriate place in the model. If this irreversible reaction is sufficiently slow, the model may be used to show that the concentrations of the species connected by reversible steps will converge to essentially their respective equilibrium ratios, even though the total mass in the reversible part of the system is not conserved. If the irreversible reaction is fast, then the equilibrium concentration ratios for the reversible system itself can never be achieved.

The Hydrodynamic Apparatus as an Analogue Computer. The sequence of composition values from starting compositions to thermodynamic equilibrium can be plotted in composition space to give a reaction path. For the three component system, the composition space is a triangular plane. For the system discussed, this plane is shown in the graph of Figure 4. The reaction paths for three starting compositions are shown. The crosses "X" show the compositions determined with the hydrodynamic model and the solid curves are the chemical reaction paths as determined from the actual chemical reaction. The data indicate that the simulation of the composition sequences for the chemical reaction by the hydrodynamic model is very good. The shaded region in Figure 4 gives the values of the amounts of the species B which are obtained by overshooting the equilibrium concentration in the course of the reaction, using an initial composition of pure species A.

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To use the apparatus as an analogue computer, one must choose the cylindrical diameters and the capillary sizes to be the proper analogue of the chemical reaction. In "The Analogies" section, it was shown that the cylinder diameters are proportional to the thermodynamic equilibrium concentrations. The proper capillary sizes are obtained from the rate expressions developed in the mathematical treatment of the two systems. For the chemical system, equation (4) can be rewritten to give

$$\frac{d}{dt}\begin{pmatrix} a \\ b \\ c \end{pmatrix} = \begin{pmatrix} -(k_2b^* + k_6a^*) & k_2b^* & k_6a^* \\ k_2b^* & -(k_2b^* + k_4c^*) & k_4c^* \\ k_6a^* & k_4c^* & -(k_4c^* + k_6a^*) \end{pmatrix} \begin{pmatrix} a/a^* \\ b/b^* \\ c/c^* \end{pmatrix} \quad (15)$$

For the hydrodynamic system, equation (10) can be rewritten to give

$$\frac{d}{dt}\begin{pmatrix} V_A \\ V_B \\ V_C \end{pmatrix} = \begin{pmatrix} -(K_1 + K_3) & K_1 & K_3 \\ K_1 & -(K_1 + K_2) & K_2 \\ K_3 & K_2 & -(K_2 + K_3) \end{pmatrix} \begin{pmatrix} h^* \dfrac{V_A}{V_A^*} \\ h^* \dfrac{V_B}{V_B^*} \\ h^* \dfrac{V_C}{V_C^*} \end{pmatrix} \quad (16)$$

Thus, it follows from these two rate equations that the correspondence between the chemical rate constants k_i and the hydrodynamic constants K_i are as follows:

$$\begin{aligned} K_1 &\leftrightarrow k_2b^* \\ K_2 &\leftrightarrow k_4c^* \\ K_3 &\leftrightarrow k_6a^* \end{aligned} \quad (17)$$

Now the values of K_i from equations (5) and (6) are given by

$$K_i = \frac{\pi(r_i)^4}{8zl_i}\rho g \quad (18)$$

where ρ is the density of the fluid and g is the acceleration due to gravity.

If all the capillaries are chosen to be of the same length, then K_i is proportional to the fourth power of the radius. Hence, to simulate the relative rate constants of the chemical reaction, the radii of the capillaries must be proportional to the following respective terms

$$\begin{aligned} r_1 &\sim (k_2b^*)^{1/4} \\ r_2 &\sim (k_4c^*)^{1/4} \\ r_3 &\sim (k_6a^*)^{1/4} \end{aligned} \quad (19)$$

The larger the constant of proportionality, the faster the hydrodynamic reaction will proceed.

The values of the capillary radii simulating composition sequences for the rate constants of the butene system were calculated by this procedure and are as follows: $r_1 = 0.80$ mm, $r_2 = 0.83$ mm, $r_3 = 0.60$ mm. The lengths of the capillaries used were 50 cm long; they were carefully heated and bent into a "U" shape, as in Figure 3. For this length capillary, experimental measurements of the flow show that Poiseuille's Law is obeyed. For much shorter capillary lengths, the flow deviates from Poiseuille's Law so that the model does not simulate a first order reaction.

Generalization of the Model

The hydrodynamic analogy can be modified to simulate the reaction of more than three species. The use of three species, however, gives a simple model and still illustrates the important rudiments of chemical reactions.

The model described simulates a first order reaction since the concentration corresponds to the volume and the volume is proportional to the height of fluid. Other reaction orders can be demonstrated by using tubes with variable cross-sectional areas. The shapes required are such that the volume of fluid is the proper function of height to simulate the reaction order. The kinetic behavior of coupled half order reactions can be demonstrated with the apparatus described if very short capillaries are used so that they approximate an orifice flow.

A simpler model than the one described may be fabricated with available laboratory equipment. One can use different size burets to represent the chemical species. The stopcocks control the starting and stopping of the reaction. The burets are connected together by capillaries and rubber tubing. The analogies and the various demonstrations mentioned in the text are all applicable to this simpler model.

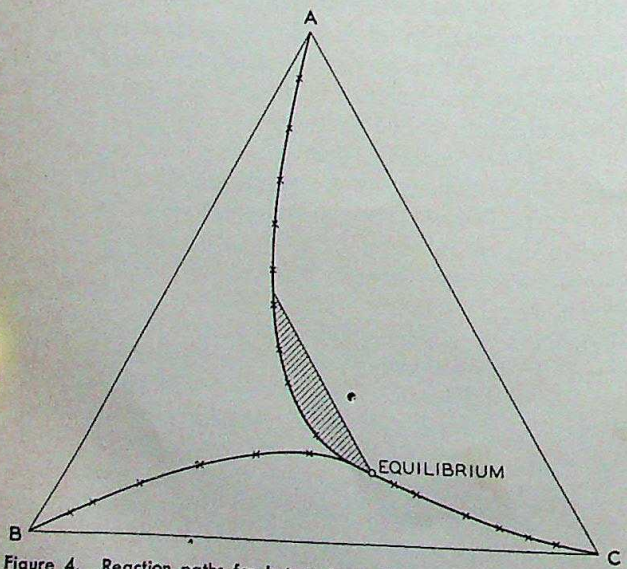

Figure 4. Reaction paths for butene isomerization. Solid lines are the true reaction paths for the chemical system; the crosses are the composition sequences obtained from the hydrodynamic analogue. The shaded portion indicates the region of overshoot of the cis-2-butene (B) equilibrium concentration for the 1-butene (A) reaction path.

Literature Cited

(1) Wei, J., and Prater, C. D., in "Advances in Catalysis," Eley, D. D., Selwood, P. W., and Weisz, P. B., eds. Academic Press, Inc., New York, 1962, Vol. 13, pp. 203–392.
(2) Weigang, O. E., Jr., *J. Chem. Educ.*, 39, 146 (1962).
(3) Onsager, L., *Phys. Rev.*, 37, 405 (1931).
(4) Tolman, R. C., "The Principle of Statistical Mechanics," The Clarendon Press, Oxford, England, 1938, p. 522.
(5) Wei, J., *J. Chem. Phys.*, 36, 1578 (1962).
(6) Wei, J., and Prater, C. D., *op. cit.*, pp. 344–355.

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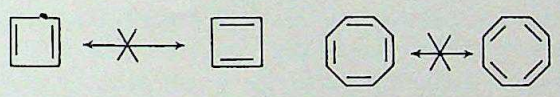
Rules for Molecular Orbital Structures

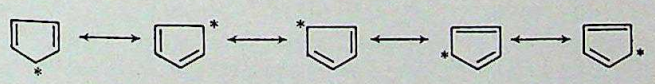
Most authors of recent general chemistry textbooks describe the electronic structure of atoms in terms of atomic orbitals. Some even discuss hybridization and molecular orbitals. Authors of recent organic textbooks make further use of molecular orbital (M.O.) theory to describe the structure of saturated and unsaturated hydrocarbons, carbonyl compounds, and carboxylic acids. However, very little use is made of M.O. theory to discuss the relationship of electronic structure and reactivity. Such discussion, which is very important in teaching organic chemistry, is almost always in terms of resonance theory.

In several instances the application of resonance theory actually leads to the wrong predictions, whereas the predictions which arise from molecular orbital theory are correct. For example, the ability to write equivalent resonance structures for cyclobutadiene and cyclooctatetrene leads to the hypothesis that these two compounds should have aromatic properties akin to benzene. Molecular orbital theory predicts that cyclobutadiene should not even exist, and that cyclooctatetrene should be an ordinary polyene with no aromaticity. Both predictions are in accord with experimental evidence.



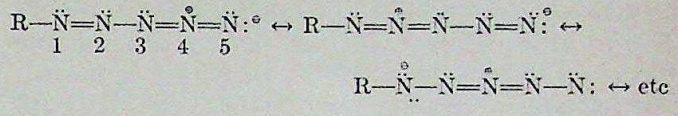
cyclobutadiene cyclooctatetrene

Resonance theory predicts that the cyclopentadienyl cation should be as stable as the anion, since in both cases five equivalent resonance structures can be written (note the following figure), each with the charge on a different carbon atom (an asterisk (*) indicates a charge).

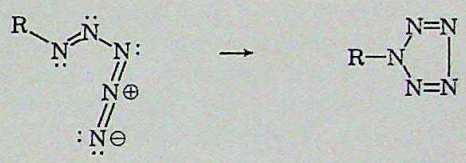


Molecular orbital theory predicts extraordinary stability for the anion, but none for the cation. In fact, the cation should be and is found to be even more reactive than otherwise expected for such an allylic structure (*1*).

The intermediate in the reaction of a diazonium salt and azide ion is a diazoazide, RN_5. Its structure is predicted by resonance theory to have five nitrogen atoms linearly arranged. This arrangement is a necessary outcome of the large number of resonance structures which can be written with multiple-bond character between each nitrogen atom.



The M.O. treatment leads to the prediction that the structure with bent angles at N_1, N_2 and N_3 is preferred; a conclusion which is in accord with the observation that these compounds readily ring-close to cyclic pentazoles (*2*), equation (1), and so must be bent.



It is true that, in most cases, the use of resonance theory leads to hypotheses which are consistent with fact. Even in these instances, however, resonance theory suffers from pedagogical drawbacks as compared with molecular orbital theory. Writing many electronic resonance structures is laborious and affords the student much opportunity to commit errors. Also, too often the student thinks that the written structures are real, and thinks of a certain structure reacting or a molecule reacting in a certain form. These misleading ideas unfortunately can easily arise as a result of the nonmathematical manner in which the concept of resonance is taught at the undergraduate level. An advantage of the M.O. theory is that only one hypothetical structure is needed to approximate the resonance hybrid which cannot be depicted by the resonance theory.

In view of the fact that M.O. theory makes more correct predictions and avoids the misconceptions which arise in the minds of novice students when they are exposed to resonance theory, it would be better to use M.O. theory as much as possible in teaching organic chemistry.

Any extension of M.O. theory, however, depends on the ease of describing and evaluating the M.O. structure. An accurate description of an M.O. structure requires a prior knowledge of bond angles and distances; information which, unfortunately, is not generally known to the undergraduate. This limitation of the use of M.O. theory can be alleviated by setting up rules to enable the student to transpose a classical electronic structure into an M.O. picture. It is true that the deduced M.O. structure is often approximate, since mixed rather than pure bond types

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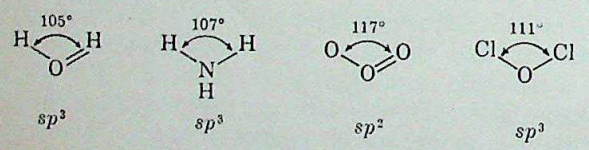
are frequently the rule; but even an approximate M.O. structure has teaching value. This paper presents and discusses a set of such rules which has been taught successfully for several years to a large number of organic chemistry students. It is hoped that these rules can augment the use of M.O. theory just as the nonmathematical rules for writing and evaluating relative stabilities of resonance structures, as suggested by Pauling and Wheland, enhanced the usefulness of resonance theory.

The ensuing rules are restricted to the second period covalently-bonded elements: Be, B, C, N, and O, since these atoms hybridize only *s*- and *p*-orbitals and not *d*-orbitals. Use of *d*-orbitals gives complicated types of bonding which cannot be easily predicted by simple rules. Although the rules are limited to these five elements, three of them, C, O, and N, are most often encountered in organic molecules and hence the rules can be applied to a large number of compounds. The rules are formulated on the assumption that *these atoms use hybrid orbitals rather than p-orbitals to form sigma bonds.* The driving force for hybridization, a process which expends energy, is the formation of a more stable covalent bond. The rules are not applied to the halogens; for when univalent, the halogens probably use unhybridized *p*-orbitals to form sigma bonds (*3*). The third period elements, such as sulfur and phosphorus, often behave in a similar manner, as shown by the values of the bond angles of approximately 90° in the compounds H_2S and PH_3. Sulfur and phosphorus can also form hybrid bonds involving *d*-orbitals in more complex molecules. Unlike Be, B, and C, oxygen and nitrogen can use *p*-orbitals rather than hybrid orbitals. Most N and O bond angles, however, are closer to hybrid values than to 90°, the unhybridized value. Typical examples are water, (*4*); ammonia, (*4*); ozone, (*5*); and chlorine monoxide, (*6*). One of the few exceptions is nitric acid, for which



the H—O—N bond angle is reported to be 90°, (*7*), a value consistent with the use of *p*-orbitals. Infrared studies (*8*) reveal that for nitrous acid, the same bond angle is 104°. A second assumption, which is unequivocal, is that *extension of π-bonds to encompass more than two atoms is preferred since the resulting delocalization of electrons stabilizes the molecule.*

Rule 1. Hybrid Orbital Number (HON)

Application of this rule gives the order of *s* and *p* hybridization, referred to as the *hybrid orbital number* (HON), (*9*). The values for the number are 2, 3, and 4, which indicate respectively, *sp*, sp^2, and sp^3 hybridization. The HON is found by adding the coordination number and the number of unshared pairs of electrons. The coordination number is defined as the number of atoms bonded to the key atom, and

$$\text{HON} = \text{coordination number} + \text{number of unshared pairs of electrons}$$

is equal to the number of sigma bonds. Table 1 lists applications of the HON rule using typical structures as illustrations. The atom, whose hybridization is being considered, referred to in this paper as the key atom, is in bold face type when the molecule contains more than one atom with hybrid orbitals.

Table 1. Applications of the HON Rule

Compounds	Coordination number	Unshared pairs of electrons	HON	Order of hybridization
CH_4, NH_4^+, BF_4^-, $BeCl_4^{-2}$	4	0	4	sp^3
$R_3C{:}^-$, $H_3N{:}$, $H_3O{:}^+$, $R_3C\cdot$	3	1	4	sp^3
$H_2\ddot{O}{:}$	2	2	4	sp^3
R_3C^+, $R_2C{=}CR_2$, BR_3, $R\overset{O}{\overset{\vert}{N}}{=}O$, $R_2C{=}O$	3	0	3	sp^2
$R\ddot{N}{=}O$, $R\ddot{N}{=}CR_2$, $R\ddot{C}{=}CR_2$	2	1	3	sp^2
$R_2C{=}\ddot{O}{:}$	1	2	3	sp^2
$RC{\equiv}CR$, $O{=}C{=}O$, $BeCl_2$, $R{-}\overset{+}{C}{=}CR_2$	2	0	2	*sp*
$RC{\equiv}N{:}$, $:C{\equiv}O{:}$	1	1	2	*sp*

A moot question is the assignment of an HON to carbon free radicals. Is the carbon in $R_3C\cdot$ sp^2 or sp^3 hybridized? There is ample experimental evidence to suggest that such a carbon does not have as stringent a coplanarity requirement as a carbonium ion and therefore is probably more sp^3 than sp^2 hybridized. Therefore, the odd electron is arbitrarily counted as a pair in the HON calculation.

Rule 2. Number of p-Orbitals and π-Bonds

Number of p-orbitals. The number of unhybridized *p*-orbitals associated with the key atom is easily determined by subtracting the HON from 4, the maximum covalency of these five atoms.

$$\text{Number of } p\text{-orbitals} = 4 - \text{HON}$$

Number of π-Bonds. These *p*-orbitals may be devoid of electrons and not be involved in any bonding; i.e., alkyl carbonium ions and boron trimethyl. More often, adjacent *p*-orbitals overlap to give a π-bond; i.e., ethylene, acetylene, and benzene. The number of π-bonds formed can be calculated by subtracting the HON from the number of pairs of electrons (bonded or lone) around the key atom. Since one *p*-orbital is needed for each π-bond, the number of π-bonds is also equal to the number of *p*-orbitals used in bonding.

$$\text{Number of } p\text{-orbitals used in bonding} = \text{Number of } \pi\text{-bonds} = \text{pairs of electrons} - \text{HON}$$

Table 2 lists some applications of this rule. An example of a key atom with both types of *p*-orbitals is found in the alkene carbonium ion, $R{-}\overset{+}{C}{=}CR_2$, see Table 2.

Rule 3. π-Bond Interactions

When structurally feasible, π-bonds overlap with each other to afford a more stable M.O. structure by augmenting the delocalization energy. Interactions of π-bonds can be classified into three main types.

Acetylenic-type π-Bond. This type of interaction arises when two adjacent atoms are mutually involved

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in two π-bonds. The two π-bonds, which are necessarily at right angles to each other, blend into one cylindrically shaped electron cloud, an acetylenic-type π-bond, Figure 1*a*. Such a bond is formed whenever two atoms are joined by a triple bond; e.g., —C≡C— and —C≡N. The maximum permissible number of electrons in an uncharged acetylenic-type π-bond is four.

Noncyclic Conjugated π-Bond. Two individual similarly oriented π-bonds can overlap laterally if they are conjugated as shown in Figure 1*b*. In a noncyclic system, the electrons in the individual π-bonds are not completely delocalized over all the participating atoms. The electrons are mainly localized within each individual π-bond because the inter-*p*-orbital overlap, as between C_2 and C_3, Figure 1*b*, is considerably less than the intra-*p*-orbital overlap, as between C_1 and C_2. The maximum number of electrons permitted in an uncharged extended π-bond depends on the number of atoms in the system. The maximum number of electrons is equal to the number of atoms, for a system possessing an even number of atoms, or equal to the number of atoms plus one, for a system possessing an odd number of atoms.

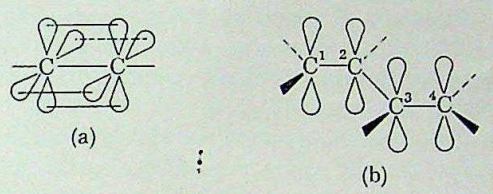


Figure 1. Types of π-bond interactions: (a) acetylene-type and (b) noncyclic conjugated-type.

Cyclic Conjugated π-Bond. Cyclic overlap of π-bonds in ring systems is predicted by Hückel's $4n + 2$ *p*-electrons rule. Systems which fit this rule are planar and possess a considerable amount of delocalization energy, because of the completeness of the overlap. Such systems are said to be "aromatic." The number of permissible electrons in the extended π-bond of a neutral molecule is the same as that found in a noncyclic system. Neutral alicyclic molecules can more easily lose or gain electrons than can neutral noncyclic polyenes, if the resulting ions fit Hückel's rule. Thus, cyclooctatetrene, a non-aromatic system with eight carbons, each with a *p*-electron, reacts with sodium to form a presumably planar "aromatic" dicarbanion which possesses ten electrons (*10*). When an sp^3 hybridized atom intrudes by preventing formation of a cyclic π-bond, the ring system generally behaves as does a noncyclic system. Those unsaturated cyclic

$$C_8H_8 + 2\,Na\cdot \rightarrow C_8H_8^{-2} + 2Na^+$$

systems, such as cyclooctatetrene which do not fit the $4n + 2$ rule, have little extended π-bond overlap, and behave as polyenes with no aromaticity.

Table 2. Applications of the Rule for *p*-Orbitals and π-Bonds

Compounds	HON	Pairs of electrons	Number of *p*-orbitals	Number of π-bonds
CH_4, H_3N:, $H_2\ddot{O}$:, BF_4^-, $BeCl_4^{-2}$, R_3C:$^-$, $R_3C\cdot$	4	4	0	0
$R_2C{=}CR_2$, $R\ddot{N}{=}\ddot{O}$:, $R_2C{=}\ddot{O}$:	3	4	1	1
BF_3, R_3C^+	3	3	1	0
$RC{\equiv}CR$, $RC{\equiv}N$:, $O{=}C{=}O$, :C≡O:	2	4	2	2
$R{-}\overset{+}{C}{=}CR_2$	2	3	2	1
$BeCl_2$	2	2	2	0

Rule 4. Extended p-Orbital Overlap

The HON rule is modified when the key atom has an unshared pair of electrons and is either adjacent to an atom involved in a π-bond; e.g.,

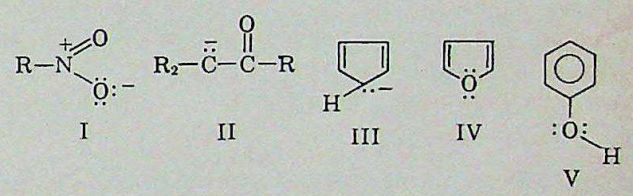
—Ä—B=C or —Ä—B≡C

or an atom with an empty *p*-orbital; e.g.,

Ä—B—
|

If the unshared pair were in a *p*-orbital, parallel to the adjacent *p*-orbital, more extended *p*-orbital overlap would occur. The resulting increase in electron delocalization would engender a more stable molecule. Therefore, the orbitals of the key atom hybridize to permit such a situation and the HON is reduced by one for every pair of electrons so involved.

Some illustrations of this rule are the nitro group, (I), a carbanion alpha to a carbonyl group, (II), the cyclopentadienyl anion, (III), furan, (IV), and phenol, (V). In each, the HON rule predicts sp^3 hybridization for the key atom. However, to permit extension of the π-bond, the hybridization is sp^2.



A problem arises concerning the extent of the change in hybridization. Hybrid orbitals are not always pure *sp*, sp^2, or sp^3. More often they are blends; i.e., sp^3 with some sp^2 character. When applying Rule 4, it is necessary to decide, at least in a qualitative manner, which is the predominant order of hybridization. A reasonable decision can be made by considering the stability of the resulting extended π-bond system. The change to the lower HON is substantial if:

(1) Extension of the π-bond engenders an aromatic system; e.g., in structures (III) and (IV);

(2) A symmetrically-charged π-bond results; e.g., in structure (I);

(3) The electrons are delocalized from a weakly electronegative element into a π-bond which involves a properly situated, strongly electronegative element. The electronegative element must be at the other end of the π-bond. If it is part of a group; e.g., NO_2 or CN, attached to a benzene-type ring, the group must be substituted at a position ortho or para to the substituent with the key atom. Structure (II), in which the carbon is weakly electronegative, is a representative example. Most of the stable carbanions; e.g., those alpha or ortho or para to a C=O, NO_2, CN, and SO_2 group, fall into this category. An increase in the number of these groups enhances the amount of sp^2 hybridization. If the electrons are delocalized from a

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neutral, strongly electronegative element into a π-bond with only weakly electronegative atoms, there is only a slight change to a lower HON. The presence of a negative charge on the strongly electronegative element augments the extension of the π-bond. For this reason, the oxygen atom in phenoxide ion has more sp^2 character than does the one in phenol.

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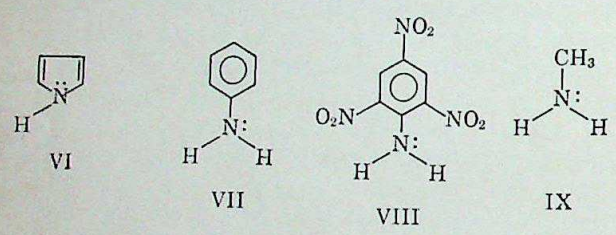
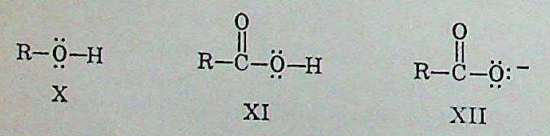
(4) For an ion, the charge is diffused to several other atoms which partake in the π-bond; e.g., benzylic ions (see later discussion of alternate polarity).

If these criteria for stability are not met, the key atom retains the hybridization predicted by the HON rule, but with some lower order hybrid character. Thus, in structure (V) the oxygen is mainly sp^3 hybridized, but with some sp^2 character. A comparison of pyrrole (VI), aniline (VII), 2,4,6-trinitroaniline (VIII), and methylamine (IX), can be used to further illustrate this discussion. In pyrrole (VI), when the pair of electrons is delocalized, the resulting cyclic π-bond possesses a total of six electrons, and the structure is aromatic. The orbitals of the nitrogen atom in pyrrole are therefore mainly sp^2 hybridized. In aniline (VII), the pair of electrons are delocalized from a strongly electronegative element into a π-bonded system with only weakly electronegative elements. The extended π-bonded system is not that much more stable than the original unextended one, and so the



orbitals of the nitrogen atom are essentially sp^3 hybridized, but with some sp^2 character. Certainly, the N atom in aniline has more sp^2 character than the N atom in methylamine (IX), which is not adjacent to a π-bond. The substitution of NO_2 groups (or other strong electron-withdrawing groups) at positions ortho and para to the amino group furnishes properly situated electronegative atoms, extends the π-bond and augments the sp^2 character of the amino nitrogen atom in (VIII).

A comparison of an alcohol (X), a carboxylic acid (XI), and a carboxylate anion (XII), affords another good illustration of this rule. The oxygen atom in the alcohol (X), has a HON of 4, and it is sp^3 hybridized.



In the carboxylic acid (XI), the oxygen atom also has a HON of 4, but it is adjacent to a π-bonded atom, and so acquires some sp^2 character. In the anion (XII), the extended π-bond is symmetrical and quite stable. Hence the O atom of (XII) uses almost completely sp^2 hybridized orbitals.

Ability to estimate the degree of extension of p-orbital overlap is very important. It permits an evaluation of relative delocalization energies of two or more *similarly constituted* molecules, and hence of differences in reactivity. It is useful to know the relative order of hybrid character which often determines reactivity; e.g., acidity and basicity.

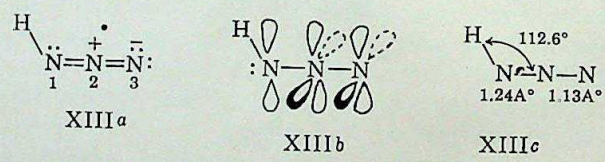
Rule 5. Limitations of Extended p-Orbital Overlap

Limitations to extension of p-orbital overlap arise because of unfavorable charge distribution in the molecule. Charge distribution, which is strongly emphasized in resonance theory, is usually neglected in qualitative M.O. theory. Rules concerned with location of charge are used to prevent writing of high energy resonance forms. Similar rules, presented in this paper couched in M.O. language, can also prevent students from drawing unstable M.O. structures.

The delocalization of a pair of electrons from the key atom into a neighboring π-bond creates positive formal charge on the atom. This salient fact is the basis for limitations of extended p-orbital overlap.

A neutral atom which has two lone pairs of electrons can only contribute one pair into an adjacent acetylenic π-bond. Contribution of two pairs would create an unfavorable formal charge of +2 on the key atom. Concomitant with the accumulation of excessive positive charge on the key atom, there would be an undesirable accumulation of negative charge elsewhere in the π-bond. For this reason even a key atom with a negative charge would not be likely to delocalize two pairs of electrons.

If the π-bonded atom next to the key atom has a positive charge, the extension of the π-bond is prevented, since adjacent positive charges would result. If, however, the key atom has a negative charge, the lower order hybridization occurs. Hydrazoic acid (XIII*a*), illustrates this limitation.



Atom 2 is undoubtedly sp hybridized (Rule 1) and has two p-orbitals which participate in two π-bonds (Rule 2). Atoms 1 and 3, by being sp hybridized, can make available another p-orbital for extended π-bonding (Rule 4). Since nitrogen atom 2 has a positive charge, application of Rule 4 is subjected to limitations imposed by Rule 5. There is no limitation on atom 3 to contribute its pair of electrons since this atom has a negative charge. The same is not true for atom 1, since it is neutral. In the deduced structure (XIII*b*), atom 1 is sp^2 hybridized and atoms 2 and 3 are sp hybridized. There are two π-bonds present; one extends over all three atoms, the other is localized over atoms 2 and 3. The experimental values for the bond angles and distances (11) in hydrazoic acid (XIII*c*) validate the deduced structure. The linearity of the three nitrogen atoms is in accord with the delocalized π-bond which encompasses the three atoms. The shortened distance between atoms 2 and 3 is expected because these atoms participate in two π-bonds. The distance between atoms 1 and 2 is less than the N—N single bond distance which indicates some π-bonding. The H—N—N bond angle of 112.6° denotes some sp^2 character for nitrogen atom 1.

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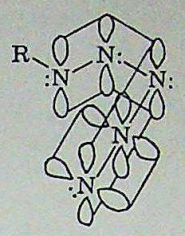
Roberts (*2*) gives a sophisticated mathematical treatment of the molecular orbital structure for a diazoazide, and concludes that the most favorable structure is



All the nitrogen atoms are involved in an extended π-bond, and the last and the next-to-last nitrogens are participants in an acetylenic-type π-bond. Application of the simple rule discussed leads to the same conclusion. As can be seen from the discussion of hydrazoic acid, a nitrogen atom which has two σ-bonds must have a positive charge if it is also involved in an acetylenic π-bond. Since the presence of adjacent positive charges is to be avoided, adjacent di-σ-bonded nitrogen atoms cannot be involved in acetylenic-type π-bonding. The only time two adjacent nitrogen atoms can be involved in such bonding is when at least one of the atoms has only one σ-bond—that is, the terminal nitrogen. In the structure under consideration, the only two nitrogen atoms which meet this requirement are the end nitrogen atom and the one next to it, N_4 and N_5. Of course, all the nitrogen atoms are involved in an extended π-bond, as shown.

Contribution of a pair of electrons from a neutral atom into a π-bond engenders charge separation. Such is not the case when an atom with a negative charge contributes a pair of electrons. Therefore, *an atom with a negative charge is more likely to acquire more of the lower order hybridization character than a similarly constituted neutral atom.* As a result, the key atom in an anion adjacent to a π-bond participates in more extensive p-orbital overlap than does the key atom in the neutral conjugate acid. The anion therefore, has more delocalization energy relative to the conjugate acid. The key oxygen atom in a carboxylate anion (XII) and in a phenoxide ion, has more sp^2 character than the same atoms respectively in the carboxylic acid (XI) and in phenol (V).

Rule 6. Effect of Cross-overlapping of p-Orbitals

When three parallel p-orbitals are arranged laterally, an extended π-bond is possible, as exemplified by the amide group, —$CONH_2$. If a third atom with a p-orbital is attached to the middle atom, a cross-overlapped π-bond results. Cross-overlapping is illustrated in Figure 2, with the aid of generalized formulas.

In Figure 2*a*, since atoms A and B are both contributing electrons into the expanded π-bond, atom Y would accumulate too much negative charge. As a result, the amount of p-orbital overlap between A, B, and Y individually with X diminishes.

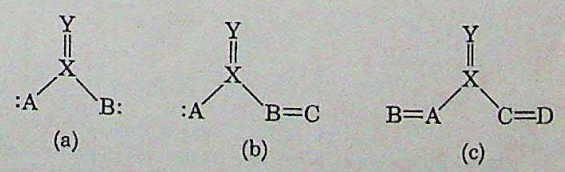
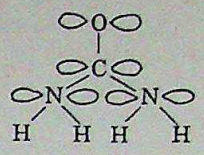


Figure 2. Illustrations of cross-overlapped π-bonds.

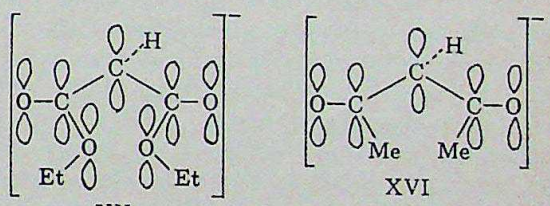
Urea (XIV), illustrates the consequences of such cross-overlapping. The p-orbital of carbon cannot overlap as well with the p-orbitals of both N atoms and



XIV

the O atom as it could with p-orbitals of just one N atom and the O atom. Experimentally, this effect is revealed by a lengthening of the C=O bond from 1.22 to 1.25 Å. The two C—N bonds are also somewhat longer than the same bond in an amide (*12*). Cross-overlapping diminishes the sp^2 character of the N atom.

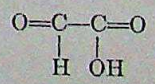
A comparison of the malonate carbanion (XV), and the acetylacetone anion (XVI), illustrates the effect of such cross-overlapping on the relative stabilities of M.O. structures. In carbanion (XVI), there is an extended π-bond involving the two carbonyl groups and the middle carbon atom. The delocalization of electrons is from carbon to the very electronegative oxygen atoms. The carbon with the unshared pair of electrons is practically completely sp^2 hybridized and the carbanion is relatively stable. In anion (XV), the carbanion carbon is cross-overlapped with the carbonyl carbon and oxygen, and with the O atom of the ethoxy group. This carbanion carbon does not have as much sp^2 character as does the one in (XVI). There is not as much delocalization of the lone pair on the carbon atom and hence (XV) is less stable than (XVI). It is



XV XVI

for this reason that a carbanion is stabilized more by an adjacent carbonyl group in an aldehyde or ketone than by a carbonyl group in an ester, amide, or other acid derivatives.

In Figure 2*b*, the effect of cross-overlapping depends on the charge density of B. If atom B is even somewhat electron-rich, as in a vinyl or phenyl group, its presence will deter the overlap of the p-orbitals of atoms A and X. Thus in benzoic acid, C_6H_5—COOH, the presence of this type of cross-overlap inhibits the overlap of the p-orbital of the OH oxygen with the π-bond of the carbonyl group. The oxygen of the OH group develops more sp^3 and less sp^2 character. If, however, B is electron-poor, as in a C=O group, the overlap of the p-orbitals of A and X is enhanced and atom A acquires more sp^2 character. As a consequence, in glyoxalic acid



the oxygen atom of the OH group has more sp^2 character than it would in an ordinary RCOOH compound.

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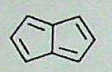
In Figure 2*c*, the structure deduced by applying the HON rule does not have to be modified because of possible extension of *p*-orbital overlap, as was the case in Figure 2*a* and 2*b*. In general, the orbitals of the four atoms involved cannot overlap as well as they could if the four were arranged laterally. Hence, such a cross-overlapped M.O. structure is not as stable as one which is conjugated, as evidenced by the fact that 3-methylene-1,4-hexadiene has less delocalization energy than its linear conjugated isomer, 1,3,5-heptatriene. This type of cross-overlapping attenuates the aromaticity of most of the so-called pseudoaromatic systems such as pentalene. Polynuclear aromatics are



cross-overlapped systems; and as a result, in naphthalene—a typical example—neither ring is as aromatic as benzene. This effect is revealed by the reduction of naphthalene by sodium in liquid ammonia, and by oxidation to 1,4-naphthoquinone.

Rule 7. Use of Maximum Number of p-Orbitals in Bonding

This rule becomes necessary when considering the M.O. structure of allene, Figure 3. Application of the HON rule gives values of 3 (sp^2) for the terminal carbons and 2 (sp) for the central carbon. Two M.O. structures are possible with this hybridization. Figure 3*b* results when the p_y- and p_z-orbitals of the central carbon, each with one electron, overlap independently with a parallel mate on the adjacent carbon atoms. This structure has two π-bonds at right angles to each other. Figure 3*c* results from an overlap of the p_y-orbitals of all three carbon atoms. The middle carbon atom has to contribute two electrons in order to satisfy the octet requirement. The p_z-orbital of the central carbon atom is devoid of electrons and is not involved in bonding. The geometry of allene fits Figure 3*b* and not 3*c*. Structures such as Figure 3*c* can be avoided by stating a rule: *a more stable M.O. structure results when the maximum number of p-orbitals are involved in bonding.* This requirement is consistent with Hund's rule, because the correct allene structure is attained when the p_y- and p_z-orbitals each possess one electron, as shown in Figure 3*b*.

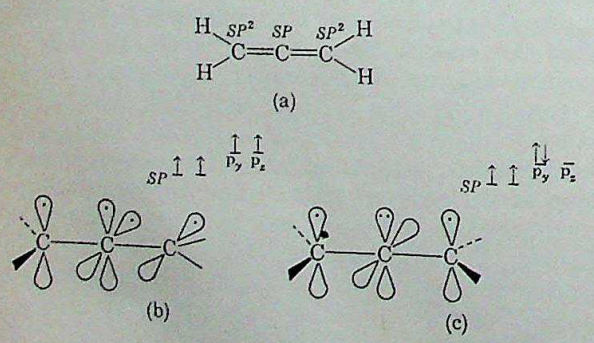


Figure 3. Possible M.O. structures for allene and atomic orbital structure of the key carbon.

There are three aspects of extended *p*-orbital overlap which have been alluded to previously but which require more detailed discussion.

It has been mentioned previously that in polysubstituted benzenes, reenforced extended *p*-orbital overlap occurs only for ortho and para substituted compounds. This effect is a consequence of alternate polarity in conjugated systems. The concept of alternate polarity, an outcome of molecular orbital theory, was suggested by Coulson (*13*) and elaborated by Longuet-Higgens (*14*). It states, in effect, that any charge density in a conjugated system is located mainly on alternate sites. In the case of a substituted benzene, Figure 4*a*, the electron disposition on atom A is distributed to the starred alternate carbons of the ring, which happen to be the ortho and para sites. If the atom A is electron-donating, the starred sites have a high electron density; whereas, if it is electron-withdrawing, the starred sites are electron-deficient. Free radical character is similarly distributed. Figures 4*b* and *c* show the alternate sites for an α- and β-substituted naphthalene. Introduction of a group, B, whose electronic character is the opposite of group A, at a starred (not an unstarred) position enhances the extended *p*-orbital overlap. Two such substituted groups with the same electronic behavior mutually retard *p*-orbital overlap.

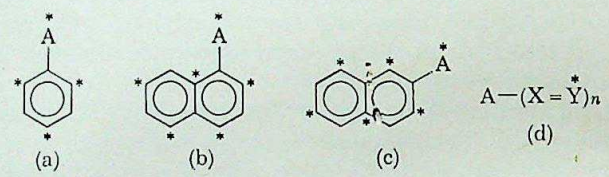


Figure 4. Examples of alternate polarity in (*a*) substituted benzene, (*b*) α-substituted naphthalene, (*c*) β-substituted naphthalene, and (*d*) substituted acyclic conjugated system.

The principle of alternant polarity can be applied to an aliphatic system. From Figure 4*d*, it is evident that the terminal atom must always be a starred site. Substitution of the group B at the terminal atom is usually most effective because there is no interference from cross-overlapping.

Extended p-Orbital Overlap and Coplanarity

Lateral orientation is necessary before adjacent *p*-orbitals can fully overlap to form an extended π-bond. Such orientation requires that the sigma bonds of the interacting atoms assume a coplanar geometry. Structural features which prevent the attainment of coplanarity impede the extension of the π-bond. Two prominent types of steric impediments are shown in Figure 5. Benzoquinuclidine, Figure 5*a*, is an A—B=C type molecule which should be capable of extended *p*-orbital overlap. However, the nitrogen atom is at a bridgehead and its three bonding orbitals cannot

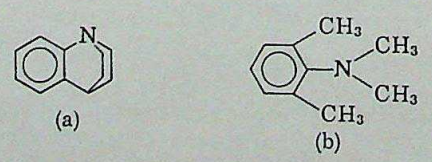


Figure 5. Types of steric impedance to extension of p-orbital overlap: (*a*) benzoquinuclidine (key atom at a bridge head) and (*b*) 2,6-dimethyl-*N,N*-dimethylaniline (ortho effect).

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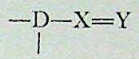
become coplanar. The nitrogen atom retains its sp^3 hybrid character and there is no extended p-orbital overlap. 2,6-Dimethyl-*N*,*N*-dimethylaniline, Figure 5*b*, is a typical example of a molecule in which there is a pronounced "ortho effect." The substituents in the two ortho positions prevent the attainment of coplanarity. The severity of the steric hindrance depends on the bulkiness of the substituents on the nitrogen atom and the ortho substituents.

Extended p-Orbital Overlap Involving Electron-deficient Atoms

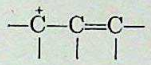
The importance of carbonium ions as intermediates in organic reactions warrants a separate discussion of the extension of π-bonds using p-orbitals of electron-deficient atoms. When an atom, D, which possesses a p-orbital devoid of electrons, is attached to either a π-bonded atom;



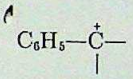
or to an atom with a lone pair of electrons; i.e.

extended π-bonding results.

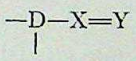
Typical examples of the former type are the allylic

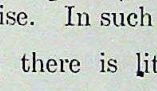


and benzylic

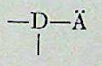


carbonium ions. In both cases the empty p-orbital on carbon overlaps with the adjacent π-bond to give fairly stable M.O. structures. If, in the system

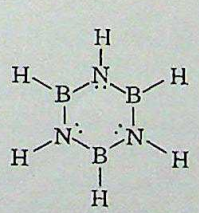


atom Y is very electronegative, an unfavorable charge distribution would arise. In such systems, as exemplified by  , there is little extension of p-orbital overlap and the carbonium ions have very high energies.

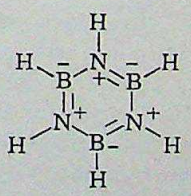
A typical example of the



type compound is borazole (XVII*a*), which might be better represented as an aromatic ring with a cyclic extended π-bond (XVII*b*).



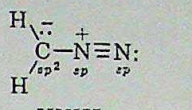
XVII*a*



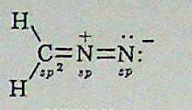
XVII*b*

M.O. Structure of Resonance Hybrids

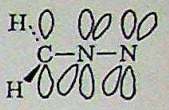
The aforementioned rules are all based on classical electronic structures. There are some molecules which can only be represented by two or more resonance structures. If the rules suggested in this paper are valid, their application should lead to the same M.O. structure starting with any one of the resonance structures. Diazomethane is such a molecule and is used to test the rules. In structure (XVIII*a*), the HON for C is 4, (sp^3) and for each N is 2, (sp). Application of Rule 2 suggests two π-bonds (an acetylenic π-bond) between the nitrogen atoms.



XVIII*a*



XVIII*b*



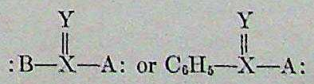
XVIII*c*

The carbon atom has an unshared pair of electrons and is attached to a π-bonded atom. Hybridization of the sp^2 type permits extended p-orbital overlap (Rule 4). The adjacent N atom has a positive charge but the C atom is negative, so the charge distribution is favorable (Rule 5). In structure (XVIII*b*) the terminal N atom and the C atom have HON values of 3 (sp^2) and the center N atom has a value of 2 (sp). By being sp rather than sp^2 hybridized, the terminal N atom can contribute a pair of electrons into an extended π-bond (Rule 4). This is possible, even though the central N atom has a positive charge, because the terminal N atom has a negative charge (Rule 5). Obviously, the same M.O. structure, (XVIII*c*) results. The structure arrived at probably closely approximates the actual resonance hybrid. It is noteworthy that *within the limitations of Rule 5, the atoms always acquire the lowest possible HON value, thus permitting the maximum amount of p-orbital overlap.*

Summary

The rules discussed in this paper can be used to hypothesize a plausible M.O. structure from a classical electronic structure as follows:

(1) Hybrid orbital number (HON) = coordination number + unshared pairs of electrons
(2) Number of p-orbitals = 4 − HON
(3) Number of π-bonds = number of pairs of electrons − HON
(4) When structurally feasible, π-bonds interact to give extended π-bonds.
(5) It is best to use a maximum number of p-orbitals for bonding.
(6) If the key atom has an unshared pair of electrons and is attached to a π-bonded atom; i.e., Ä—B=C, hybridization occurs to permit the pair of electrons to enter a p-orbital and extend the π-bond. For each pair of delocalized electrons, the HON value is reduced by one unit. Such delocalization induces a positive increase in formal charge on the key atom and an increase in formal negative charge elsewhere in the π-bond.
(7) Extended p-orbital overlap is considerable if: an aromatic system results; a symmetrical M.O. structure results; or delocalization of electrons is from a weakly electronegative atom into a π-bond with a strongly electronegative atom at the other end of the π-bond, or at an ortho or para position of a benzene-type ring.
(8) Extended p-orbital overlap is minimal if: cross-overlapping with an orbital of an electron-rich atom is present, i.e.,



charge separation results; delocalization is from a strongly electronegative element into a π-bonded system with weakly electronegative elements.
(9) Extended p-orbital overlap does not occur if: adjacent like charges arise, or a formal charge on the same atom of more than +1 or −1 results.

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Application of these rules should broaden the use of molecular orbital theory, especially in the study of the relationship of electronic structure and reactivity.

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Acknowledgment

The author wishes to express his gratitude to his colleagues, Professors Francis E. Condon and Samuel Wilen, and to Drs. Jean Dayan and Leonard Schwartz, whose searching questions led to the development of many of the ideas described in this paper.

Literature Cited

(1) Streitwieser, A., Jr., "Molecular Orbital Theory for Organic Chemists," John Wiley and Sons, Inc., New York, 1961, pp. 269–273.
(2) Roberts, J. D., "Notes on Molecular Orbital Calculations," W. A. Benjamin, Inc., New York, 1961, pp. 131–9.
(3) Cartmell, E., and Fowles, G. W. A., "Valency and Molecular Structure," Butterworth's Scientific Publications, London, 1956, p. 99.
(4) Mellish, C. E., and Linnett, J. W., *Trans. Far. Soc.*, 50, 657 (1954).
(5) Trambarulo, R., Ghosh, S. N., Burrus, C. A., and Gordy, W., *J. Chem. Phys.*, 21, 851 (1953).
(6) Dunitz, J. D., and Hedberg, K., *J. Am. Chem. Soc.*, 72, 3108 (1950).
(7) Maxwell, L. R., and Mosley, V. M., *J. Chem. Phys.*, 8, 738 (1940).
(8) Jones, L. H., Badger, R. M., and Moore, G. E., *J. Chem. Phys.*, 19, 1599 (1951).
(9) Condon, F. E., and Meislich, H., "Introduction to Organic Chemistry," Holt, Rinehart and Winston, Inc., New York, 1960, p. 235.
(10) Katz, T. J., *J. Am. Chem. Soc.*, 82, 3784, 3785 (1960).
(11) Amble, E., and Dailey, B. P., *J. Chem. Phys.*, 18, 1422 (1950).
(12) Wells, A. F., "Structural Inorganic Chemistry," Clarendon Press, Oxford, 1950, p. 518.
(13) Coulson, C. A., "Valence," Oxford University Press, London, 1952, p. 238.
(14) Longuet-Higgins, H. C., *Proc. Chem. Soc.*, 1957, 159.

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A Quantitative Experiment with Paper Chromatography

Experiments in the qualitative separation of metallic ions by paper chromatography have been rather widely used in general chemistry or qualitative analysis; but few, if any, paper chromatography experiments have been introduced into quantitative work. A procedure developed in this laboratory for the separation and determination of cobalt, copper, nickel, and zinc[1] has been combined with more recent methods for the spectrophotometric determination of cobalt and nickel[2,3] and adapted to student use. The amount of time (approximately six three-hour laboratory periods) required for the experiment is not considered excessive since the student receives training in several techniques and principles.

A glass pipet cleaning jar, 46 × 15 cm, covered with a desiccator top serves as a convenient chamber. A slide staining dish atop a 38- × 3.8-cm hydrometer cylinder may be used as the solvent reservoir for preparing descending chromatograms on strips of Whatman No. 3 mm filter paper.

The Experiment

Solvent I. 60 ml *n*-butyl alcohol, 11 ml water, 5 ml 12 *M* HCl. Mix just prior to use.

Solvent II. 50 ml acetone, 42 ml 3-methyl-2-butanone, 6 ml 6 *M* HCl. Mix just prior to use.

Indicators. 0.01% solution of dithizone in CCl_4. Keep refrigerated. 0.01% solution of rubeanic acid in 1 *M* NaOH solution. Prepare fresh daily.

Solution of Metallic Ions. The following weights of the anhydrous salts are used in preparing 250 ml of solution: 0.7778 g ZnO dissolved in 10 ml 6 *M* HCl, 1.5695 g $CuSO_4$, 0.5508 g $CoCl_2$, and 3.3125 g $NiCl_2$. This solution contains 2500 ppm of copper, 2500 ppm of zinc, 1000 ppm of cobalt, and 6000 ppm of nickel.

Buffer Solution. Mix 1 part of 0.2 *M* boric acid with 9 parts of 0.05 *M* borax to obtain a *p*H of 9.0.

Color reagents. The reagent for copper and zinc is prepared by dissolving 0.130 g of Zincon (LaMotte Chemical Products Co., Chestertown, Md.) in 2 ml of 1 *M* NaOH and diluting to 100 ml with water. This solution should be freshly prepared each week. The reagent for nickel and cobalt is prepared by dissolving 0.291 g of 1,2,3-cyclohexanetrione trioxime (Eastman No. 7660) in 100 ml of 95% ethyl alcohol.

For each chromatographic jar to be used, cut six paper strips 43 cm long, and fold each strip 3 and 3.5 cm from one end. Apply 25 lambda of the standard solution of the ions across 5 of the 6 strips per jar at a point 3 cm below the second fold. Five chromatograms are run to insure against trouble in subsequent steps and still to have two results for reporting. The volume applied will contain 62.5 μg of each zinc and copper, 25.0

[1] Frierson, W. J., Rearick, D. A., Yoe, J. H., *Anal. Chem.*, 30, 468 (1958).
[2] Frierson, W. J., Patterson, N., Harrill, H., Marable, N., *Anal. Chem.*, 33, 1096 (1961).
[3] Frierson, W. J., Marable, N., *Anal. Chem.*, 34, 210 (1962).

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μg of cobalt, and 150.0 μg of nickel. The sixth strip, without any ions, is carried through the same chromatographic procedures and the section corresponding to a given ion is cut, eluted, and used as the reagent blank in the spectrophotometric determinations. Mix the components of solvent I and pour it into the slide staining dish. The dish is placed on top of the hydrometer cylinder which is standing in the pipet jar. Cover the jar and allow it to become saturated with the vapor of the solvent (20 to 30 min). Hang the strips over the edge of the dish so that all the folded edges dip into the solvent to the same extent. The strips should be held in place with a glass slide and should not be allowed to touch each other or any of the glassware below the edge of the dish. Allow the solvent to migrate down the strip for 17–24 hr or until the zinc is 4–6 cm from the end of the strip. In most cases a faint brown line on the strip indicates the position of zinc; however, if this line does not show up, one strip must be removed and developed with the dithizone in order to determine when all strips are to be removed. During this time the solvent will begin to drip off the end of the strip and the cobalt, nickel, and copper will remain near the point of application. The relative positions of the ions are shown in Figure 1. After migration is complete, remove the strips and allow them to dry.

At the second laboratory period, while the jar is becoming saturated with solvent II, swab the lower 8 cm of one strip from each jar with the dithizone reagent to locate the zinc band. Using this developed strip as a guide, clip off the lower section of all the strips cutting 1–2 cm above the indicated position of the zinc. Hang the remaining upper portion of the original strips in solvent II. Allow this separation to proceed until

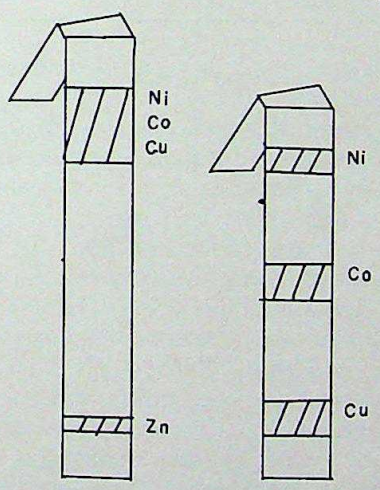

Figure 1. Left, position of the ions after using solvent I. Figure 2. Right, position of the remaining ions after using solvent II.

the yellow copper band has moved to 6 cm from the end of the strip, (4–5 hr). In most runs a blue band near the center of the strip shows the position of cobalt; however, the rubeanic acid test as described will definitely show the position of cobalt if the blue band does not appear. Develop one strip immediately while it is still damp by hanging it in ammonia vapor until the copper band turns blue and then by swabbing the entire strip with the rubeanic acid solution. The copper will now appear as a green band near the bottom of the strip, (4–5 hr). In most runs a blue band near the center of the strip shows the position of cobalt as a yellow band near the center, and the nickel as a blue band near the top. Figure 2 shows the relative positions of the three ions after using solvent II. While this separation is in progress, elute the zinc by cutting the strip to a slight point at the end nearest the zinc band, creasing the other end and hanging in 0.1*M* HCl contained in a Petri dish. The Petri dish is mounted on an inverted beaker such that the eluting liquid from the short strips can be conveniently caught in small beakers. This arrangement is placed inside a desiccator or other container which can be kept closed during the elution. The elution should be complete in two hours when about 2 ml of the eluate has collected in the beaker. Before the strips are removed it is advisable to place about 10 drops of the eluting acid at the top of the strip so that it may flow down the strip and elute any remaining ions. Do not allow the eluates to evaporate before the spectrophotometric determinations are made. A Beckman DU spectrophotometer with 1.0 cm cells was used in making the measurements.

In subsequent laboratory periods cut from the strip separate sections for each nickel, cobalt, and copper, and elute each individually: the nickel with 0.1 *M* HCl, and the cobalt and the copper with 3 *M* HCl. The following methods are recommended; the references will supply complete directions.

Copper and Zinc. Transfer the eluted ions to 50 ml volumetric flasks, add 20 ml of borax-boric acid buffer and 3 ml of the Zincon solution. If the *p*H does not check between 8.5 and 9.5 use ammonia to adjust it. Dilute to 50 ml with water, mix well, and make absorbance measurements at 620 mμ against a reagent blank.[1]

Cobalt. To the eluate add 0.8 ml of the solution of 1,2,3-cyclohexanetrione trioxime, adjust the *p*H between 3 and 4, transfer to a 10 ml volumetric flask and dilute with water. After 30 min make absorbance readings at 400 mμ against a reagent blank.[2]

Nickel. To the eluate add 3 ml of 1.0% gelatin solution and 0.75 ml of the solution of 1,2,3-cyclohexanetrione trioxime. The *p*H normally falls in the correct range of 3–6, but any necessary adjustments may be made with ammonia or hydrochloric acid. Transfer to a 10 ml volumetric flask and dilute with water. Absorbance measurements are made at 560 mμ against a reagent and gelatin blank.[3]

All water used should be redistilled since very small amounts of ions present in it will interfere.

The amount of each ion recovered from the chromatograms is read from Beer's law absorbancy graphs for concentrations in the ranges of 1.0–25 ppm of nickel, 1.0–5.0 ppm for cobalt, and 0.5–2.0 ppm for copper and zinc. These graphs may be determined by using aliquots of stock solutions of the various ions to prepare solutions of known concentrations in the appropriate ranges and then treating these solutions according to the given procedure. Once these curves have been prepared, they may be used from year to year with fairly good results. Students with no previous training in any of the special techniques involved can readily achieve an accuracy of 2 to 10%.

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The Present and Future of Qualitative Analysis

Report of a Survey

The survey upon which this report is based was suggested by Dr. Theodore A. Ashford, Chairman of the Examinations Committee of the Division of Chemical Education at the March, 1962, working sessions of the Brief Qualitative Analysis Subcommittee. Its purpose was to determine to what extent new concepts in the teaching of chemistry have affected the content and place in the curriculum of courses in qualitative analysis. The information provided has served as a guide in the preparation of a new Brief Qualitative Analysis Examination to be published in 1964 and will aid the Examinations Committee in planning future examinations.

Copies of the questionnaire used and additional information may be obtained from the author.

The Survey

The questionnaire was designed to give a maximum of information with a minimum of effort on the part of the recipient. Despite its 6-page length, estimated average completion time was one-half hour. Responses to the 14 questions were multiple choice requiring a check mark. Comment space was provided.

The 500 questionnaires were sent to chemistry departments meeting one or more of the following requirements: accreditation by the ACS, recent use of ACS examinations in Qualitative Analysis, or interest in chemical education evidenced by membership in the Division of Chemical Education. Geographical location and type of institution were varied for broad coverage.

The completed questionnaire was returned or letters of explanation were written by 94% of the 500. A total of 458 (91.6%) of the questionnaires were available for analysis. These 458 questionnaires covered 543 courses involving over 100,000 students.

Selected Data from the Questionnaires

The fact that approximately 1800 IBM cards were required to record the questionnaire answers is an indication of the wealth of information that is available. In the summary which follows, responses have been grouped into fairly broad ranges where practical, and material pertaining specifically to ACS examinations in qualitative analysis has been omitted. The section headings are essentially the questions which appeared on the questionnaire and the tables are numbered to correspond. In general, the interpretation of the data is left to the reader.

What is the place of inorganic qualitative analysis in your program? Comparison of Table 1 with previous survey data[1,2] shows a continuation of the trend toward inclusion of qualitative analysis with general chemistry and elimination of the separate course. An unpublished survey by W. C. Oelke in 1958 covering 133 institutions showed 49% giving qualitative analysis only in the freshman year, 22% giving an advanced course only, and 26% giving both.

Table 1. Place of Qualitative Analysis in Chemistry Program

	Number	%
General	252	55.0
Separate qual	90	19.7
Analytical	16	3.5
General and qual	64	14.0
General and analytical	24	5.2
Qual and analytical	3	0.7
All three	2	0.4
None	7	1.5
Total number giving qual as:		
Part of general	342	63.0
Separate course	156	28.7
Part of analytical	45	8.3
Total number of courses covered by survey	543	

How many students per year enroll in courses including qualitative analysis? The purpose of this question was to permit a check of the distribution of the data with respect to department size and to provide an estimate of the number of students covered by the survey. Since nearly 25% of the colleges and universities in the United States returned questionnaires and the method of sampling favored larger institutions, the coverage in terms of students in Table 2 is probably 30–40%.

How many semester hours are devoted to classroom work in qualitative analysis? Table 3 gives an idea of the relative emphasis on qualitative analysis theory in different courses and at different institutions. In this table and all which follow, qualitative analysis in analytical chemistry is omitted since only 45 of the 543 courses covered by the survey were of this type.

How many semester hours are devoted to laboratory work in qualitative analysis? Table 4 shows that the

[1] J. Chem. Educ., 17, 220 (1940).
[2] J. Chem. Educ., 27, 675 (1950).

Table 2. Number of Students Taking Qualitative Analysis Courses

No. students per year	Under 50		50–99		100–299		300–499		Over 500		Approx. totals
	No.	%	No.	%	No.	%	No.	%	No.	%	
Gen chem	44	13.0	67	19.9	136	40.0	40	11.8	52	15.3	95,000
Sep qual	88	55.3	33	20.8	32	20.1	3	1.9	3	1.9	14,500
Anal chem	32	71.1	7	15.6	6	13.3	0	0.0	0	0.0	1,500
										Total	110,000

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Table 3. Total Semester Hours Devoted to Classroom Work

No. semester class hours	Under 20 No.	%	20–39 No.	%	Over 40 No.	%	Average hours per semester
General chem	117	65.2	91	27.3	25	7.5	18
Separate qual	20	14.0	100	63.7	35	22.3	31

Table 4. Total Semester Hours Devoted to Laboratory Work

No. semester lab hours	Under 30 No.	%	30–59 No.	%	Over 60 No.	%	Average lab hrs per semester
General chem	80	23.4	157	48.6	85	28.0	46
Separate qual	5	3.2	43	27.0	111	69.8	66

Table 5. System Used for Separation and Identification of Cations

System	Hydrogen sulfide No.	%	Thio-acetamide No.	%	Non-sulfide No.	%	Macro No.	%	Semimicro No.	%
General chem	109	31.3	227	65.2	12	3.5	35	10.7	292	89.3
Separate qual	49	31.2	101	64.3	7	4.5	6	3.9	149	96.1

average laboratory time for qualitative analysis in general chemistry is approximately two-thirds of the average for separate courses, a considerably larger fraction than for classroom time as shown in Table 3. It should be noted that the ratio for classroom time would be larger if time spent in the lecture course in general chemistry on theory basic to qualitative analysis were to be included. Some may have included this, but probably most did not.

What system is used for the separation and identification of cations? The figures in Table 5 show that thioacetamide is replacing hydrogen sulfide but perhaps not as rapidly as might be expected. There has been some criticism of ACS qualitative analysis examinations on the basis that sulfides are too much emphasized. This appears not to be justified.

What cations are identified in the laboratory? Table 6 indicates that in qualitative in general chemistry, there is a definite tendency to limit the laboratory work to a select list of cations. In the separate qualitative course, no ion on the list was covered by less than 90%. The list for the separate course has not changed significantly since Oelke's 1958 survey. As might be predicted, as qualitative analysis is shifted to general chemistry, ion coverage in this type of course becomes more complete than when a separate course also was offered. Oelke's report shows five cations in the range 44–63%; in this study the lowest coverage was 66.3%.

What anions are identified in the laboratory? Table 7 shows that anion analysis continues to be much less popular than cation analysis with only 6 ions covered by more than 90%. As was true of the cations, coverage in the qualitative in general courses has increased since the earlier surveys were made. Average coverage of the 22 ions common to both the 1958 and the present surveys increased from 42% in 1958 to 56% in 1962.[3]

What relative emphasis is given to the topics listed below? The topics listed in Table 8 were selected after consulting a number of qualitative analysis texts. Space

[3] The questionnaire provided space for cations and anions identified but not listed. Under "Qualitative Analysis in General Chemistry" the *total* number of additional cations and anions was 56. For "Separate Qualitative Analysis" the number was 71. In addition to anions derived from different oxidation states of elements in the standard list, cations and anions from a total of 12 additional elements were included. Of these, the ions of Li, Mo, Si, Tl, Ti, W, U, and V were most popular.

Table 6. Order of Preference for Cations

Qual in general chemistry Cation	%	Separate qual Cation	%
Ag^+	98.9	$Fe^{2+,3+}$	100.0
$Fe^{2+,3+}$	97.4	Ag^+	99.3
Pb^{2+}	97.4	Pb^{2+}	99.3
Cu^{2+}	97.1	Cu^{2+}	99.3
Al^{3+}	93.5	Na^+	99.3
Hg^{2+}	93.0	Al^{3+}	98.7
Hg_2^{2+}	92.4	Ni^{2+}	98.7
Ba^{2+}	91.5	Ba^{2+}	98.7
Ca^{2+}	91.2	Mn^{2+}	98.7
Cr^{3+}	90.3	Cr^{3+}	98.1
Zn^{2+}	90.0	Zn^{2+}	98.1
K^+	88.6	K^+	98.1
Na^+	88.3	Ca^{2+}	98.1
NH_4^+	87.1	Co^{2+}	98.1
Mn^{2+}	86.5	NH_4^+	97.4
Mg^{2+}	84.8	Mg^{2+}	97.4
$Sn^{2+,4+}$	83.9	Hg^{2+}	97.4
Ni^{2+}	81.5	Hg_2^{2+}	97.4
Bi^{3+}	78.9	Cd^{2+}	97.4
Co^{2+}	77.1	Bi^{3+}	96.8
Cd^{2+}	76.2	$As^{3+,5+}$	96.8
$As^{3+,5+}$	69.8	$Sn^{2+,4+}$	94.9
Sb^{3+}	68.9	Sb^{3+}	93.0
Sr^{2+}	66.3	Sr^{2+}	91.1

Table 7. Order of Preference for Anions

Qual in general chemistry Anion	%	Separate qual Anion	%
None	12.6	None	11.3
Cl^-	98.3	Cl^-	96.4
SO_4^{2-}	96.8	SO_4^{2-}	95.7
CO_3^{2-}	92.9	Br^-	95.7
Br^-	92.5	I^-	95.0
I^-	91.5	NO_3^-	94.3
NO_3^-	90.0	CO_3^{2-}	93.6
S^{2-}	77.7	SO_3^{2-}	87.9
PO_4^{3-}	74.4	PO_4^{3-}	87.2
SO_3^{2-}	69.9	S^{2-}	86.5
CrO_4^{2-}	53.1	CrO_4^{2-}	80.1
NO_2^-	43.7	NO_2^-	70.2
$C_2H_3O_2^-$	42.7	$C_2O_4^{2-}$	62.4
AsO_4^{3-}	39.9	AsO_4^{3-}	62.4
F^-	26.5	SCN^-	60.9
$C_2O_4^{2-}$	26.2	$C_2H_3O_2^-$	60.2
MnO_4^-	25.5	F^-	45.3
$Cr_2O_7^{2-}$	24.5	$S_2O_3^{2-}$	43.2
$S_2O_3^{2-}$	23.5	MnO_4^-	41.8
SCN^-	22.8	$Fe(CN)_6^{4-}$	40.4
BO_2^-, etc.	13.8	$Fe(CN)_6^{3-}$	39.7
$Fe(CN)_6^{4-}$	12.1	$Cr_2O_7^{2-}$	38.2
$Fe(CN)_6^{3-}$	11.4	ClO_3^-	30.3
ClO_3^-	10.4	BO_2^-, etc.	28.4

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Table 8. Relative Emphasis Given to Topics

Qual in general chemistry Topic	%	Separate qual Topic	%
Redox equations	95	Solubility product	98
Solubility product	94	Common-ion effect	97
Ionization equilibria	93	Ionization equilibria	95
Common-ion effect	91	Hydrolysis equilibria	92
Solution concentration	90	Solution concentration	88
Acid-base theory	89	Complex ion equilibria	86
Amphoterism	81	Redox equations	85
Hydrolysis equilibria	79	Acid-base theory	83
Solution properties	77	Amphoterism	82
Complex ion equilibria	73	Solution properties	70
Oxidation potential	69	Complex ion structure	62
Ionic size and properties	57	Oxidation potential	58
Complex ion structure	52	Ionic size and properties	46
Indicators	52	Indicators	42

limitations imposed a certain lack of clarity as to what the topic included. The use of terms which tend to lose their significance in modern acid-base theory led, as expected, to some criticism. There is an obvious difficulty in deciding to what extent the topics are covered in qualitative analysis apart from the general chemistry in the category of "qualitative in general chemistry." The choices were strong, medium, and slight emphasis and the numbers which appear in the table are the total checks for the first two choices expressed as percentages.

What relative emphasis is given to the equation types and methods for balancing of oxidation-reduction reactions? The numbers in Table 9 are total percentages for strong

Table 9. Relative Emphasis Given to Equation Types and Balancing Methods

	Gen chem %	Sep qual %
molecular equations	54	40
Ionic equations	93	90
Redox equations	91	92
Non-redox equations	70	61
Oxidation number balancing	69	62
Ion-electron balancing	79	77

and medium emphasis. There was some objection to the term "molecular" equations in a field where true molecules are admittedly rare, but the results would indicate that equations for ionic reactions are still being written in molecular form.

What relative emphasis is given to the types of numerical problems listed? The numbers in Table 10 have the

Table 10. Relative Emphasis Given to Types of Numerical Problems

Qual in general chemistry Problem type	%	Separate qual Problem type	%
pH and H^+ concentration	93	Application of solubility product	98
Ionization equilibria	92	Calculation of solubility product	96
Application of solubility product	91	Ionization equilibria	96
Common ion effect	90	Common ion effect	94
Calculation of solubility product	88	pH and H^+ concentration	93
Concentration of solutions	79	Hydrolysis equilibria	89
Hydrolysis equilibria	75	Concentration of solutions	86
Based on equations	74	Complex ion equilibria	79
Complex ion equilibria	57	Based on equations	58

same significance as in Tables 8 and 9. The agreement on the top 5 problem types is striking, the differences in order of preference are based on very small actual differences.

What changes are planned in your treatment of qualitative analysis in the next three years? Table 11 gives some

Table 11. Changes Planned in Treatment of Qualitative Analysis in the Next Three Years

	Qual in general chemistry		Separate qual	
	No.	%	No.	%
No changes planned	199	59.4	75	48.7
Increase class time	26	19.1	14	17.7
Decrease class time	16	11.7	9	11.3
Increase lab time	25	18.3	3	3.7
Decrease lab time	36	26.4	16	20.2
Drop from program	3	2.2	21	26.5
Add to program	5	3.6	0	0.0
Change to semimicro	8	5.8	3	3.7
Change to thioacetamide	17	12.5	5	6.3
Change to non-sulfide	4	2.9	2	2.5

insight into the future of qualitative analysis. The separate course in qualitative analysis appears to be losing ground at an accelerating rate.

Conclusions

The survey summarized in this report is based on a representative sample of sufficient size to yield valid results. The continued decline of qualitative analysis as a separate course is definitely established. However, the rate of decline has been slower than many have assumed. Despite the fact that the separate course beyond the freshman year is apparently disappearing from the curriculum, it seems likely that qualitative analysis as a part of general chemistry will endure and even gain in popularity. Many of those completing the survey questionnaire wrote in defense of qualitative analysis as an effective means of teaching chemical equilibrium and, to a lesser extent, laboratory technique. New approaches to qualitative analysis are being tried at many institutions. What evolves may differ radically from traditional qualitative analysis, but it seems certain that the new qualitative analysis will be more modern in its theory and less routine in its practice.

Acknowledgment

To all who contributed to the success of the qualitative analysis survey, my sincere thanks. The list is long: Dr. Ashford for suggesting the survey and contributing to the high return by sending a follow-up letter; the Examinations Committee for financial support; the Brief Qualitative Analysis Subcommittee for assistance in preparing the questionnaire and analyzing the returns; Dr. Albertine Krohn, secretary of the Subcommittee, for constructive criticism and many hours of labor; Miss Sarah Hamill, Program Director of the Examinations Committee, for valuable assistance and encouragement; Professor Robert Mason, University of Toledo Statistics Department, for expert advice in constructing the questionnaire and finally, my wife, for accepting lonely evenings with uncomplaining understanding.

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Notes on Qualitative Analysis

EDITOR'S NOTE: The following papers have been collected over a period of months. A similar collection appeared in previous August issues (J. CHEM EDUC., 35, 401 (1958); 36, 379 (1959); 37, 407 (1960); 38, 406 (1961); 39, 395 (1962)). It is the Editor's hope that collection into one place will prove more attractive to readers than the more frequently used editorial procedure of scattering items such as these through the pages of several issues. We apologize to authors who thus have had to wait to see their work in print.

We commend to readers' attention the fact that often these represent the solution of problems given to freshman students in qualitative analysis courses. We hope that publication in these pages can stimulate just such activity. If readers merely incorporate these ideas into their own laboratory instructions, our battle is only half won. If, beyond that, these ideas suggest to the readers that they use their own ingenuity in similar fashion, we are gratified.

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Separation and Identification of Copper in the Presence of Cadmium

In the classical analytical procedures both copper and cadmium are precipitated together, and the separation and identification of cadmium is made in the presence of cyanide ion by precipitation with H_2S. Only cadmium sulfide is precipitated because the stability constant of the copper cyanide complex is greater than that of the corresponding cadmium complex.

Due to the highly poisonous character of HCN, various methods have been described for the separation of both elements without HCN.[1] Vick and Harris[2] used anionic ion exchange resins to retain the complex anion formed between cadmium and bromium ions; cadmium was then eluted with ammonium hydroxide and precipitated with H_2S.

We suggest two modifications of their technique for separation and identification of cadmium when copper is present.

Separation of Copper with Cupferron

Cupferron, the ammonium salt of nitrosophenylhydroxilamine and a common analytical reagent, precipitates copper from acid solutions but not cadmium. The copper cupferrate is filtered off or extracted with chloroform.

Precipitation. Into a beaker pipet copper solution (1 mg/ml) and cadmium solution (1 mg/ml), add sufficient sulfuric acid to make a 5% solution, and precipitate at room temperature with 10 ml of 1% freshly prepared cupferron solution. Filter using a medium porous paper, and wash the precipitate with a few milliliter of water, slightly acidified with sulfuric acid. Copper is identified by adding a few drops of 1:1 NH_4OH to the precipitate to develop the characteristic blue color.

To the filtrate add sufficient NH_4OH to make a slightly ammoniacal solution. Then add some thioacetamide crystals and warm. Observe the yellow cadmium sulfide precipitate.

Extraction. Pipet into a separatory funnel cadmium and copper solutions, add enough H_2SO_4 to make a 5% solution, and adjust the volume to 20–30 ml. Add 5 ml cupferron solution and extract with 5 ml chloroform. Allow the two phases to separate and discard the organic phase into another separatory funnel. Repeat the extraction three times. To the collected organic phases add a few milliliter 1:1 NH_4OH and shake. Let the phases separate. Observe copper and cadmium as above.

Cation Exchange—EDTA Separation

An ion exchange column (0.8 cm id × 5 cm) is mounted with strong cation exchange resin (Nalcite HCR, 30–50 mesh). The resin is conditioned with 10 ml 1 *M* HCl and washed with water until the effluent shows no acidity.

To the solution containing the cadmium and copper ions (5 mg each) add 100 mg of ethylenediaminetetraacetic acid (EDTA) dissolved in a minimum of NH_4OH, and adjust the *p*H of the solution to 1–3 with HNO_3. Percolate the solution (about 15 ml) through the column at about 2 ml/min and wash the column with 30 ml 5 g/l EDTA prepared in a minimum of NH_4OH and at a *p*H of 1–3 measured at the time of the experiment. The blue EDTA-Cu complex is not absorbed by the cation resin, but the cadmium ions are.

After washing the column with EDTA, elute the resin with 15 ml of 1.0 *M* HCl into a small beaker, warm the eluate on a hot plate, and add thioacetamide crystals. Then add 3 ml 1:1 NH_4OH and cover the beaker with a watch glass. Observe the yellow CdS precipitate.

If necessary, copper may be directly identified in the blue effluent by adding a few drops of 5% aqueous ferrocyanide solution.

[1] See, for example, WHITEHEAD, T. H., AND HATCHER, G. K., THIS JOURNAL, 39, 399 (1962) and the references noted therein.
[2] VICK, M. M., AND HARRIS, E. L., THIS JOURNAL, 38, 414 (1961).

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Dissolving Difficultly Soluble Salts with Chelating Ion Exchange Resins

Chelating resins such as Dowex A-1 and Chelex 100 can be represented by the formula $RN(CH_2CO_2Na)_2$ in the sodium form. Reactions of the type

$$2RN(CH_2CO_2^-)_2 + BaSO_4 \rightarrow Ba(RN(CH_2CO_2)_2)_2^{-2} + SO_4^{2-}$$

provide a new way of separating the ions of some difficultly soluble salts. In qualitative analysis the unknown is first ground fine and then mixed with the wet resin (50–100 mesh). The mixture is allowed to stand, possibly with heating, until only the resin beads are visible. The resin is rinsed with water which is then tested for anions. The cations are eluted with 6 *M* HNO_3.

The table shows approximate dissolving times, at room temperature, for a number of compounds. The very stable complex, HgI_4^{2-}, is also decomposed by the resin. Complete removal of I^-, however, requires rinsing the resin with about 50 times its volume of water. Possibly mercury is first held as $RN(CH_2CO_2)_2HgI^-$. The elution of Hg^{2+}, Ag^+, and Cr^{3+} from the resin is more difficult than that of other cations. The first two are reduced to the metals in the presence of residual NaOH which can be washed out in the regenerated resin. Rapid and essentially quantitative elution of the three ions requires, respectively, at least 6 *M* HNO_3, conc. HNO_3, and either aqua regia or Na_2O_2, with destruction of resin in the last cases. The presence and removal of chromium ions are easily revealed by color.

Acknowledgment. This work was part of a study aided by the Research Corporation. The experimental work was done by Duane D. Schroeder.

Dissolving Times at Room Temperature

Compound	Dissolving time
$PbSO_4$	5–10 min
PbI_2	5–10 min
$PbCrO_4$	30 min
$Pb_3(PO_4)_2$	30 min
$BaSO_4$	1–6 hr
$Ba_3(PO_4)_2$	15 min
CaF_2	1 hr
AgCl	30–45 min
AgI	1 hr
HgI_2	30–45 min
$Mn_3(Co(CN)_6)_2$	10–15 min
$Zn_3(Co(CN)_6)_2$	15 min

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Non-Cyanide Detection of Cadmium

There has been a revival of interest recently in the non-cyanide detection of cadmium in the presence of copper.[1–3] The trend of modifications has been towards developing wholly inorganic methods; however, most of the methods have limitations.

We have examined a large number of well known organic reagents for the purpose of achieving a clean separation. The difficulty is to find a reagent which would precipitate copper and cadmium at a widely separated *p*H range. After a series of trials with reagents such as quinaldinic acid, acetoacetanilide, benzohydroxamic acid, benzimimazole, 2-mercaptobenziminazole, biguanide sulfate, *N*-benzoyl phenylhydroxylamine, and rubeanic acid, we have developed the following method which works well.

The method assumes that currently used scheme of analysis is followed where cadmium and copper are left in solution as the tetrammines.

Procedure. The test solution is treated with biguanide acid sulfate (2% aqueous solution) and the medium made sufficiently ammoniacal. Copper separates quantitatively as bright rose-red copper bisbiguanidinium sulfate.[4] This precipitate is then filtered and the filtrate treated with the reagent *N*-benzoyl phenyl hydroxylamine (1% 1 : 1 aqueous-alcoholic solution). The presence of cadmium is indicated by a heavy white, crystalline precipitate.

[1] Chandra, R., J. Chem. Educ., 38, 409 (1961).
[2] Clifford, A., "Inorganic Chemistry of Qualitative Analysis, Prentice-Hall, Inc., New York, 1961, p. 136.
[3] Whitehead, T. H., and Hatcher, G. K., J. Chem. Educ., 39, 399 (1962).
[4] Ray, P. and Roy Chowdhury, J., *J. Indian Chem. Soc.*, 18, 149 (1941).

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A Simple Separation of the Group II-A Sulfides

In 1958 Lehrman[1] commented on the unreliability of the method described in most textbooks on qualitative analysis for separation of lead and bismuth. He pointed out that when sulfuric acid is used some lead may stay in solution or some bismuth may precipitate, and he proposed the use of ammonium sulfate to separate these two cations. More recently Whitehead and Hatcher[2] have reviewed the methods for non-cyanide separation of copper and cadmium and have suggested a separation based on precipitation of copper as an acetylide from ammoniacal solution. These authors comment on the possible explosive nature of the copper(I) acetylide. This danger may not be great when the precipitate is wet, but it seems distinctly possible that the precipitate may be left by a student in a test tube and that on drying it would present a great hazard.

A group separation scheme, which uses simpler methods for the separation of lead from bismuth and of copper from cadmium than those reported above was set out in a textbook first published in 1955[3] and is given below.

In an attempt to isolate a pure sample of ^{210}Bi from ^{210}Pb, the usual separation of lead and bismuth as sulfates was checked by the present author using tracer techniques. This separation was found to be very inefficient and was abandoned in favor of a new one based on the use of sodium hydroxide, which was found to be very effective.[4] In practice in qualitative analysis the lead-bismuth separation in the scheme below is easy to apply because sodium hydroxide solution is added to the centrifuged and washed mixed hydroxides of lead and bismuth. Under these conditions there are no difficulties associated with adjusting reagent concentrations.

The basis of the copper-cadmium separation is that cadmium sulfide is completely soluble in 3 to 4 *M* hydrochloric acid, whereas copper(II) sulfide is not. If the values of pK_1 and pK_2 for hydrogen sulfide are taken as 7.2 and 14.2, the ionic product calculated for cadmium sulfide in a solution 0.1 *M* in cadmium, 4 *M* in hydrochloric acid and saturated with hydrogen sulfide would be 3×10^{-25}—a value greater than the generally accepted value of the solubility product, 1×10^{-28}. It is shown in another communication[5] that chloride ion concentration must be considered as a factor in addition to acidity in discussing the solubility of cadmium sulfide in hydrochloric acid solutions. Again, a practical advantage of this separation is that hydrochloric acid is added directly to the solid mixed sulfides and steps such as neutralization and controlled dilution are avoided. The reappearance of cadmium sulfide when ammonia is added to the acid solution after removal of copper(II) sulfide is very easy to detect and normally resaturation with hydrogen sulfide is unnecessary. It is suggested in the directions simply as a precaution.

[1] Lehrman, L., J. Chem. Educ., 35, 406 (1958).
[2] Whitehead, T. H., and Hatcher, G. K., J. Chem. Educ., 39, 399 (1962).
[3] Brown, R. D., and O'Donnell, T. A., "Manual of Elementary Practical Chemistry," Melbourne University Press, 1st ed., 1955, 3rd ed., 1963.
[4] O'Donnell, T. A., *Australian J. Chem.*, 8, 493 (1955).
[5] O'Donnell, T. A., J. Chem. Educ., 40, A313 (1963).

Separation of Group II-A Cations

Group precipitate contains sulfides of Hg^{++}, Bi^{+++}, Cu^{++}, Cd^{++}, and Pb^{++}. Heat with 6 drops water and 3 drops 14 M HNO. Centrifuge.

- *Residue:* Black HgS. May be white $Hg(NO_3)_2$, 2 HgS, containing $PbSO_4$. Treat washed residue with 2.5 *M* ammonium acetate solution and 1 *M* acetic acid. Centrifuge.
  - *Residue:* HgS or $Hg(NO_3)_2$, 2 HgS. Dissolve in aqua regia, dilute and verify Hg^{++} with $SnCl_2$.
  - *Solution:* May contain Pb^{++}.
- *Solution:* Contains Bi^{+++}, Pb^{++}, Cu^{++}, and Cd^{++}. Neutralize with 13 *M* ammonia and add 3 drops excess.
  - *Precipitate:* $Bi(OH)_3$ and $Pb(OH)_2$. Add 10 drops 2 *M* NaOH. Stir, warm, and centrifuge.
    - *Residue:* $Bi(OH)_3$
    - *Solution:* Contains plumbite
  - *Solution:* Contains $Cu(NH_3)_4^{++}$ and $Cd(NH_3)_4^{++}$ Saturate solution with H_2S. Centrifuge.
    - *Precipitate:* CuS, CdS. Treat with 3–4 *M* HCl. Centrifuge.
      - *Residue:* CuS
      - *Solution:* Contains Cd^{++}. Make almost neutral and saturate with H_2S
        - *Precipitate:* CdS
    - *Solution:* Discard

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Preparation of Solutions for Qualitative Analysis with a Cation Exchange Resin

Most students taking qualitative analysis find the dissolution of insoluble salts prior to analysis one of the most frustrating and discouraging aspects of the laboratory work. Usually, the student is advised to boil the unknown salt(s) in a strong solution of sodium carbonate. A metathesis occurs; the majority of salts are converted to the carbonate with the anions originally in the unknown in solution with the excess sodium carbonate. After filtering and washing, the carbonate residue is dissolved in nitric or perchloric acid to give a solution of the initially insoluble cations.

A simple technique utilizing an ion exchange resin has been developed which eliminates most of the difficulties encountered in the more classical approach. This idea has, in principle, been suggested previously,[2,3] but it has not been adapted to any conventional analysis procedures. The fundamental idea is very simple and can be explained easily to beginning students. When a strong cation exchange resin on the hydrogen cycle is mixed as a slurry with either soluble or relatively insoluble salts, the cations are retained by the resin and an equivalent amount of hydrogen ion is released:

$$RSO_3H + MX = RSO_3M + H^+ + X^-$$

The solution in equilibrium with the resin contains the anions originally present in the unknown. If the resin is now treated with nitric or perchloric acid, the metal ions are released and a solution of all the cations initially in the unknown is obtained:

$$RSO_3M + H^+ + NO_3^- = RSO_3H + M^+ + NO_3^-$$

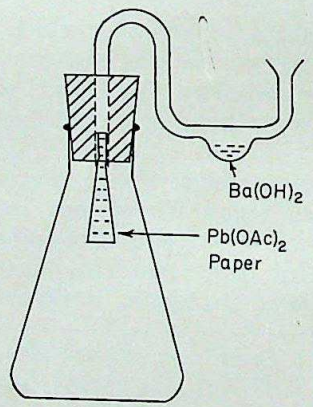
This procedure, therefore, allows the student quite simply to divide his unknown into two solutions, all the anions in one and all the cations in the other.

When carbonate or sulfide anions that evolve gases when treated with strong acid are present, the acid form of these anions might be lost during the treatment of the unknown with the resin. This difficulty can be circumvented by treating the unknown with the resin in an Erlenmeyer flask which is fitted with a rubber stopper and a glass tube as shown in the figure (see also cover photograph). Furthermore, by having a piece of moist lead acetate paper stuck in the glass tube and 2 or 3 drops of barium hydroxide solution in the bulb, the presence or absence of the two anions, namely, sulfide and carbonate, can be detected immediately.

Procedure

Treat 5 g of a strong cation exchange resin (Amberlite IR-120, Dowex 50, Permutit RS, preferably 50–100 mesh) with 10 ml of 6 *M* hydrochloric acid and gently stir or shake the mixture for 5 min. Filter the mixture and wash the resin with distilled water until a 2- or 3-ml portion of wash liquid shows no turbidity when a drop of 0.1 *M* silver nitrate is added (absence of chloride ion). It is necessary to repeat this acid and washing treatment of the resin as long as the supernatant liquid with the 6 *M* hydrochloric acid is colored. Traces of iron are frequently associated with ion exchange resins and this must be removed before the resin is satisfactory for use.

Put the 5 g of acid-treated resin in a 50-ml Erlenmeyer flask, add 50 to 100 mg of the unknown and 10 ml of distilled water. Immediately insert the rubber stopper that has been fitted with a glass tube containing a piece of moist lead acetate paper and 2 or 3 drops of barium hydroxide solution. Warm to 60–80 °C and



occasionally swirl or agitate the mixture for 15–20 min. Observe the lead acetate paper to see if it turned black indicating the presence of sulfide and the barium hydroxide solution to see if a white precipitate is present indicating carbonate. Filter the mixture and wash the resin with three 5-ml portions of distilled water. The filtrate is an acid solution of the anions present in the unknown and is ready for analysis.

Transfer the resin to a small beaker and add 5 ml of 6 *M* nitric acid. Warm the mixture to 40–50 °C for 2 or 3 min and then cool. Filter the mixture and wash the resin again with three 5-ml portions of distilled water. This filtrate is a nitric acid solution of all the cations originally present in the unknown and can be analyzed by any scheme for the systematic detection of cations. The ion exchange resin is now ready for use again with another unknown.

Results

This technique for dissolving salts and preparing solutions for qualitative analysis not only does not introduce any foreign ions but also eliminates many interferences. If phosphate is present in a solution,

[1] The first three authors are members of the Class of 1966 at The College of Wooster. This work was performed as an independent study project in the General Chemistry class.
[2] Honda, M., Yoshino, Y., and Wabiko, T., *J. Chem. Soc. Japan, Pure Chem. Sec.*, **73**, 348 (1952).
[3] Osborn, G. H. *Analyst*, **78**, 220 (1953).

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for example, it must be removed before Group III cations are precipitated in order to prevent precipitation of Group IV cations as the phosphates along with Group III. The ion exchange procedure effects an initial separation of the phosphate from the cations.

A variety of relatively insoluble salts and mixtures of these salts was treated by the recommended procedure. The salts listed all gave good tests for both the anion and cation except, of course, for the oxides which gave no anion test. Only aluminum oxide gave no satisfactory test for the cation. When a mixture of calcium carbonate and cadmium sulfide was analyzed by this procedure, both anions and cations were detected. These salts gave good tests: $PbSO_4$, $BaCO_3$, CaF_2, $BaSO_4$, $CaCO_3$, Hg_2Cl_2, CuO, ZnS, BiOCl, As_2O_3, CdS, $PbCrO_4$, PbO, FeS, HgI_2, and CaS.

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Qualitative Detection of Ba, Sr, and Ca Ions

The alkaline earth group is difficult to separate because the similarity of properties of Ba^{++}, Ca^{++}, and Sr^{++} make detection difficult. The following procedure was developed which works well with Ba^{++}, Ca^{++}, and Sr^{++} in pairs or combination of the three.

With a slight excess of $(NH_4)_2CO_3$ the alkaline earths will precipitate. This precipitate should be washed in dilute $(NH_4)CO_3$. Place 30–50 mg in a small test tube, and dissolve with dilute HCl, adding an extra drop. Add 10 drops 1 *M* $(NH_4)_2SiF_6$ and agitate. $(NH_4)_2SiF_6$ is available commercially but may be made by reacting an excess of Si with HF to form H_2SiF_6 and then neutralizing with NH_4OH. The intermediate product H_2SiF_6 is also available commercially. If Ba^{++} is present, a precipitate will form. Filter or centrifuge the $BaSiF_6$, and add 1 *M* $(NH_4)_2SO_4$ to the filtrate. If a precipitate forms which does not dissolve in one drop of concentrated HCl, Sr^{++} is indicated. By filtering off the $SrSO_4$ and adding 10 drops of 2 *M* NH_4F to the filtrate, a cloudy precipitate of Ca^{++} will form.

EDITOR'S NOTE. The author of this note worked out the scheme while a sophomore in Arrowhead High School, Hartland, Wisconsin. He will be a senior in the fall of 1963. His home laboratory is a busy place with experiments under way on adsorption, electrolytic reactions and plans for using C^{14}-tagged gibberellins in a project on plant cancer.

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Iodide Ion as a Qualitative Reagent: Detection of Nitrite and Sulfite

During the investigation of the use of I^- for detection of Sn^{4+} and Sb^{3+} (*1*), interesting reactions with several other ions were observed. In this paper we present methods for the detection of NO_2^- and SO_3^{2-} which we believe have definite advantages over those currently in use (*2–6*). The test for SO_3^{2-} will work in the presence of the other common sulfur-containing anions, and the test for NO_2^- is specific. Both procedures have been used during the past year by the 150 students in our sophomore course in qualitative analysis with excellent results.

Detection of Nitrite

The reaction of NO_2^- with I^- in acid solution is well known.

$$2\,I^- + 4\,H^+ + 2\,NO_2^- \rightarrow 2\,NO + 2\,H_2O + I_2$$

We have observed that if a small excess $Na_2S_2O_3$ is added after the evolution of I_2, the I_2 color will disappear in the solution but reappear in less than a minute *on the walls of the test tube above the solution.* This color can be removed by shaking, but will soon reappear on the walls of the test tube. This procedure can be repeated several times before the brown I_2 color disappears completely. The I_2 color on the walls will not be evident unless the test tube is left open after shaking, which indicates that atmospheric O_2 is necessary for the reaction.

The reactions described above were observed when a mixture of NO and NO_2, prepared by reacting Cu with dilute HNO_3, was passed into a test tube containing an acidified KI solution. We have thus concluded that the NO and NO_2 liberated by acidification

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of NO_2^- are responsible. The oxides of nitrogen are functioning much as they do in the lead chamber process, with the NO being oxidized by atmospheric O_2 and the NO_2 then being reduced by I^-.

$$2\,NO_2^- + 2\,H^+ \rightarrow NO_2 + NO + H_2O$$
$$2\,NO + O_2 \rightarrow 2\,NO_2$$
$$NO_2 + 2\,H^+ + 2\,I^- \rightarrow I_2 + NO + H_2O$$

Although other oxidizing agents will oxidize I^- to I_2, only NO_2^- will produce the color on the walls of the test tube after reduction of the excess I_2 with $Na_2S_2O_3$. There is no interference from NO_3^- since it does not oxidize I^- except at very high acidity.

Saturated solutions of KI and $Na_2S_2O_3$ were used for the test. The saturated solution of KI was made 0.02 *M* in $Na_2S_2O_3$ to prevent air oxidation of the KI.

The following procedure is recommended:

To 5 drops of the sample (approximately 0.1 *M* in NO_2^-) add 10 drops of saturated KI and 2 drops of dilute HCl. If NO_2^- or certain other oxidizing agents are present, a large quantity of I_2 will be produced. Add saturated $Na_2S_2O_3$ solution drop by drop with shaking until the I_2 color in the solution has disappeared. If NO_2^- is present, the brown color of I_2 will appear in less than a minute on the walls of the test tube above the solution. The color will disappear on shaking and then reappear. This can be done several times before the brown I_2 color disappears completely.

Using the above procedure it is possible to detect NO_2^- when present in 0.01 *M* solution. For NO_2^- concentrations below 0.03 *M* it is best to use a more dilute solution of $Na_2S_2O_3$ to reduce the excess I_2 rather than the saturated solution.

Students are cautioned not to add too much $Na_2S_2O_3$ in discharging the I_2 color. One or two drops of saturated $Na_2S_2O_3$ usually is sufficient to reduce the I_2. A reduction in the number of times the I_2 will reappear on the walls of the test tube, or complete failure of the test, will result from excessive amounts of $Na_2S_2O_3$. Slow decomposition of the $Na_2S_2O_3$ in acid solution will in time liberate enough SO_2 to impart some yellow color to the solution (see below).

Detection of Sulfite

The fact that SO_3^{2-} reacts with KI in acid solution to produce a yellow color has been mentioned in several recent abstracts. Kopylova (*7*) has investigated the production of KI by the reaction

$$I_2 + SO_2 + 2\,KHCO_3 + BaCO_3 \rightarrow 2\,KI + BaSO_4 + 3\,CO_2 + H_2O$$

and reports that if excess base is not present, bright yellow substances are formed which he believes to be $KI \cdot 2SO_2$, $KI \cdot SO_2$, or $KI \cdot 4SO_2$. Witekowa and co-workers have studied the reaction between HI and SO_2 at a liquid gas interface (*8*) and in solution (*9*) and have reported the existence of the complex $SO_2 \cdot HI$, which has an absorption maximum at 4000 Å. These authors report a formation constant at 25° of 0.319 and attribute the reaction to dipole-dipole interaction.

Whatever the composition of the yellow species may be, it provides an excellent method for the detection of SO_3^{2-} which can be used in the presence of S^{2-}, $S_2O_3^{2-}$, and SO_4^{2-}. Use of this reaction as a quantitative method for the determination of SO_3^{2-} is being investigated in this laboratory. Qualitatively, it is possible to detect SO_3^{2-} when present in concentrations of 0.005 *M* or greater. The color in 0.1 *M* solution slowly disappears over a period of 5 hours. The solubility of the yellow species in the common organic solvents was studied. The color was not extracted by C_6H_6, CCl_4, $CHCl_3$, CS_2, or C_2H_5I, but appeared to be partially extracted by ethyl ether.

The following procedure is recommended:

To 5 drops (approximately 0.1 *M*) of the sample add 10 drops of saturated KI and 2 drops of dilute HCl. The immediate appearance of a yellow color confirms the presence of SO_3^{2-}.

Thiosulfates, when treated in the same manner, will react slowly to produce a precipitate of S and a yellow color from the SO_2. Unless the concentrations of $S_2O_3^{2-}$ and H^+ are very high, no decomposition of $S_2O_3^{2-}$ will occur for 2–3 minutes, and students have no difficulty in testing for SO_3^{2-} in the presence of $S_2O_3^{2-}$.

Ions which oxidize KI will interfere with the test. AsO_4^{3-}, MnO_4^-, and CrO_4^{2-} are not compatible with SO_3^{2-}. Interference by NO_2^- may be prevented by precipitation of SO_3^{2-} with $Ba(OH)_2$. The precipitate of $BaSO_3$ is then washed with water and treated with saturated KI and HCl. Since it is difficult to remove all the NO_2^- by washing, some yellow I_2 color may appear on treatment with KI and HCl. If the yellow color is I_2, it can be reduced with 0.1 *M* $Na_2S_2O_3$. If the yellow color is due to SO_3^{2-}, it will not be affected by addition of $Na_2S_2O_3$.

$Fe(CN)_6^{3-}$ interferes because of its yellow color and also because the yellow color is enhanced on treatment with KI and HCl. The cause of the latter reaction is unknown and is a subject for further investigation in this laboratory. It is possible to separate SO_3^{2-} from $Fe(CN)_6^{3-}$ by treatment with $Ba(OH)_2$ as described above.

The cations As^{3+} (*1*), Sb^{3+} (*10–12*), Sn^{2+} (*1*), Sn^{4+} (*1*), and Bi^{3+} (*13*) also form yellow colors with saturated KI. The yellow Bi and Sb species are believed to be BiI_4^- (*13*) and SbI_4^- (*11–12*), respectively. The composition of the Sn and As species is unknown.

Literature Cited

(1) Paul, A. D., and Gibson, J. A., *Proc. W. Va. Acad. Sci.*, **34**, 67–9 (1962).
(2) Moeller, T., "Qualitative Analysis," McGraw-Hill Book Co., Inc., New York, 1958, pp. 214–6, 221–3, 389–91.
(3) King, E. J., "Qualitative Analysis and Electrolytic Solutions," Harcourt, Brace and Co., Inc., New York, 1959, pp. 516–20, 548–50.
(4) Nordman, J., "Qualitative Testing and Inorganic Chemistry," John Wiley and Sons, Inc., New York, 1957, pp. 382–4.
(5) Evans, W. L., Garrett, A. B., and Sisler, H. H., "Semimicro Qualitative Analysis," Ginn and Co., Boston, 1957, pp. 114, 116–7.
(6) Feigl, F., "Spot Tests in Inorganic Analysis," 5th ed., Elsevier Publishing Co., Amsterdam, 1958, p. 307.
(7) Kopylova, M. N., *Trudy Khar'kov. Farm. Inst.*, **1**, 123–30 (1957); *C. A.*, **54**, 24077 (1960).
(8) Witekowa, S., and Witek, T., *Roczniki Chem.*, **31**, 437–47 (1957); *C. A.*, **52**, 850 (1958).
(9) Witekowa, S., Paryjczak, T., and Witek, T., *Zeszty Nauk. Politech. Lodz*, No. 22, *Chem.* No. 7, 17–34 (1958); *C. A.*, **53**, 1975 (1959).
(10) Fauchon, M. L., *J. Pharm. Chim.*, **25**, 537–41 (1937).
(11) McChesney, E. W., *Anal. Chem.*, **18**, 146–9 (1946).
(12) Holler, A. C., *Anal. Chem.*, **19**, 353–5 (1947).
(13) Ahrland, S., and Grenthe, I., *Acta Chem. Scand.*, **11**, 1111–30 (1957).

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University of Oklahoma
Norman

Control and Measurement of Water Activity

The quantitative removal of water from chemical systems is difficult to achieve. It is equally difficult to maintain systems at accurately known relative humidities. The present communication describes equilibration techniques which may be used to dry organic solutions or to bring them to a known water activity in a short period of time. These techniques may also be used with volatile solutes other than water.

Recently we have been investigating the effect of dissolved water on the association equilibria of hydrogen-bonding solutes in organic solvents.[1,2] Although the partition or distribution method is suitable for studies at nearly unit water activity, we wanted to study systems at other fixed activities of water. Consequently, we wanted to develop a solute isopiestic equilibration technique, in which the volatile solute, water, would be distributed by vapor contact between a phase of known water activity and the organic solution. We expected equilibration to take place slowly (since solvent isopiestic methods are slow) but were surprised to find that a constant water activity is attained in solvents such as benzene or CCl_4 within a few hours.

The solute isopiestic apparatus is shown in Figure 1. Bottle B is a chemical reagent bottle of approximately 1500 ml capacity, to which is cemented a 6-in. test tube T. In thermostating the device, the test tube fits over

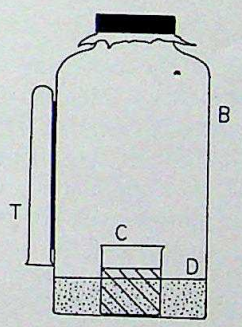

Figure 1. Solute isopiestic apparatus.

a vertical metal rod in a constant temperature bath, allowing the bottle to float in an upight position. The 100 ml beaker C contains a solution or solid of known relative humidity—for example; aqueous $CaCl_2$, a crystalline hydrate, or a drying agent such as $Mg(ClO_4)_2$. Solution D, outside the beaker, is the phase to be equilibrated at the known, constant water activity. In closing the system from the atmosphere, a piece of aluminum foil is molded over the top of the bottle, and the cap is placed over it. Air is not removed from the apparatus, and no provision is made for stirring either the solutions or the vapor.[3]

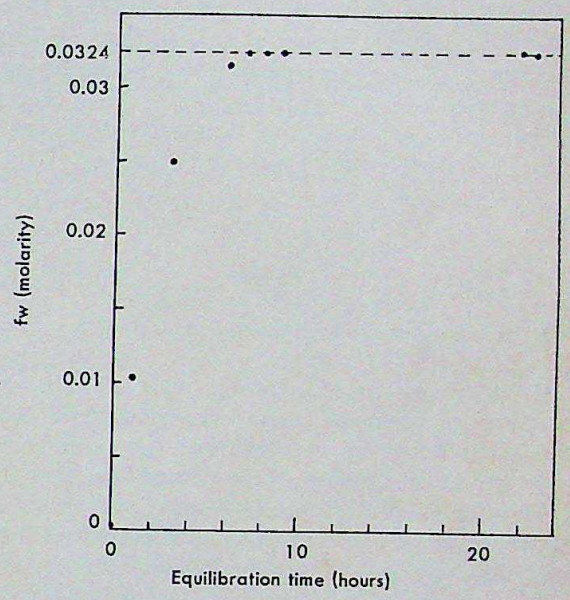

Figure 2. Equilibration rate data (25.0°).

Typical equilibration rate data are shown in Figure 2, for an experiment in which nearly dry benzene was used for solution D, and an aqueous solution of $CaCl_2$ of water activity 0.905 was placed in beaker C. Formal concentrations of water in benzene, f_w, (determined by Karl Fischer method, with coulometric end point) are plotted versus equilibration time. It appears that equilibrium has been attained in less than 10 hours—the half-life for the process is roughly 1 hour.

Encouraged by the success of the equilibration technique, we decided to attempt to solve another critical problem involving water. In near infrared spectral studies (using the Beckmann DK-1 extended range spectrophotometer) we could detect small, variable concentrations of water in CCl_4 solutions, no matter how carefully we handled them. Therefore, we constructed hollow caps which would contain a drying agent and fit the tapered neck of the spectrophotometer cells; one of these caps is depicted in Figure 3. Water vapor can transfer from the solution in the cell, through the vapor phase, to the drying agent P.

This research was supported in part by the National Institutes Health.

[1] Christian, S. D., Affsprung, H. E., and Taylor, S. A., *J. Phys. Chem.*, 67, 187 (1963).

[2] Taylor, S. A., Christian, S. D., and Affsprung, H. E., presented at the Southwest Regional Meeting of the American Chemical Society, Dallas, Texas, December, 1962.

[3] Note that in solvent isopiestic studies it is virtually mandatory to remove air and to stir the solutions. See, for example: Dailey, G. W., et al., J. Chem. Educ., 38, 28 (1962), and Baes, C. F., *J. Phys. Chem.*, 66, 1629 (1962).

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Figure 4 is a rate curve for the drying of a CCl_4 solution in a 2 cm cell (initially containing a water concentration of 0.0071 M) using P_2O_5 as the desiccant. The absorbance of the peak at 2.671 microns (on a log scale) is plotted versus time. It was determined that Beer's law is obeyed at this wavelength; a molar absorptivity of 29 liter mole^{-1} cm^{-1} was obtained for water concentrations in the range 0.002 to 0.010 molar. Figure 5 shows the dependence of absorbance on wavelength at various times after attaching the drying cap to the spectrophotometer cell. The water fundamental frequencies at 2.671 and 2.743 microns do not appear to shift with concentration, nor does the absorbance ratio of these peaks change as water is removed. It is seen from Figures 4 and 5 that the desiccation process is very rapid, having a half-life for removal of water of about 57 minutes in this experiment. In practice we use two drying caps; one on the reference cell and the other on the cell containing the solution being investigated. It is possible, of course, to equilibrate solutions at arbitrary water activities by placing constant humidity solutions in the drying cap. Note that this technique for controlling water activity obviates the need for dry-box manipulations.

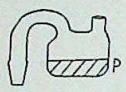

Figure 3. Drying cap for spectrophotometer cell.

The surprising rapidity with which equilibration takes place in the experiments described here can be explained in terms of two factors—the large average activity difference between the constant humidity phase and the organic solution, and the relatively small total amounts of water which must be transferred to or from the organic phase. These conditions are in direct contrast to those prevailing in solvent isopiestic experiments, where large volumes of solvent must be transferred at very small mean activity differences.

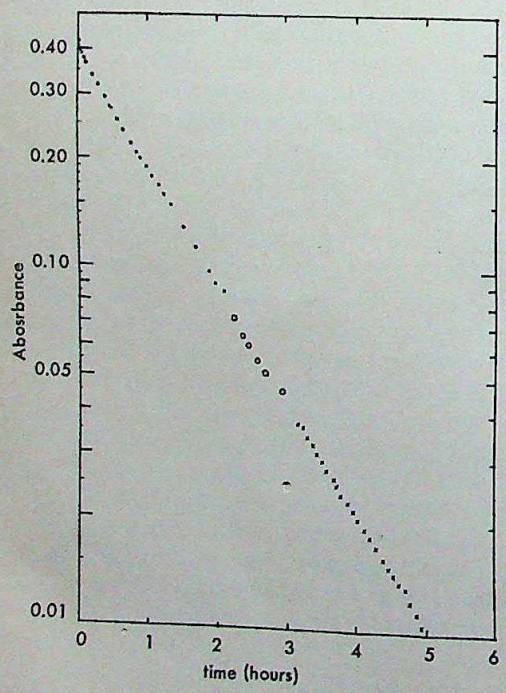

Figure 4. Absorbance at 2.671 microns versus drying time. Points ●, O and x were taken from 0 to 1 absorbancy, 75 to 125% transmission and 90 to 100% transmission scales, respectively.

Experiments analogous to partition studies can be performed using equilibrators of the type shown in Figure 1. A volatile solute, such as ethanol or acetic acid, may be distributed between two solvents, which need not be immiscible. If the concentration of solute is determined in both solutions, and if the relation between solute activity and concentration is known in one of the solutions, the dependence of activity on concentration in the other solution can be inferred.

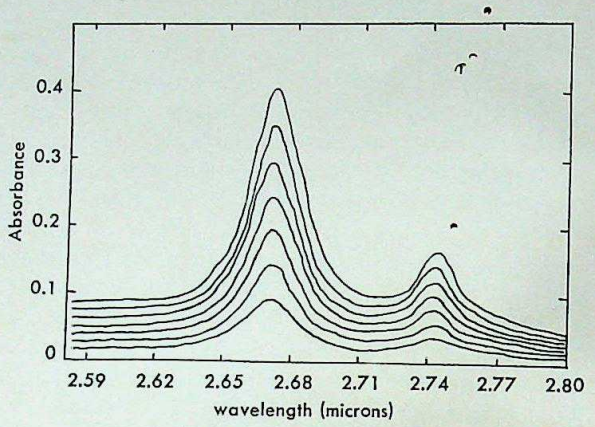

Figure 5. Absorbance curves for water in CCl_4 at 26° at various times during the drying process. Scans were made at times 0, 11 min., 22 min., 37 min., 57 min., 1 hr. 23 min. and 1 hr. 57 min. after placing the drying cap on the spectrophotometer cell.

Even if the solvents are somewhat volatile, equilibrium will be reached with respect to the volatile solute before significant quantities of solvent have been transferred.

It is interesting to speculate how the properties of the volatile solute would affect the rate of equilibration, using equilibrators similar to the one pictured in Figure 1. The following rate equation might be expected to hold for the equilibration process:

$$dc_s^D/dt = k(p_s^C - p_s^D) \quad (1)$$

where p_s^C represents the constant partial pressure of solute in the solution in C, p_s^D is the variable partial pressure of the solute in solution D, t is equilibration time, and k is a function of the geometry of the equilibrator and the diffusion coefficients of the solute in the solution and vapor phases.[4] If Henry's law is valid for solution D, c_s^D can be replaced by

$$c_s^D = (p_s^D/p_s^C)\, c_s^{D,\infty} \quad (2)$$

where $c_s^{D,\infty}$ represents the final concentration of solute in D, corresponding to the equilibrium partial pressure p_s^C. Substituting this expression into equation (1), the rate equation becomes

$$dp_s^D/dt = k(p_s^C/c_s^{D,\infty})(p_s^C - p_s^D) \quad (3)$$

Equation (3) may be integrated to yield

$$\ln[p_s^C/(p_s^C - p_s^D)] = k(p_s^C/c_s^{D,\infty})t \quad (4)$$

where it has been assumed that initially $p_s^D = 0$. The half-life for equilibration is

$$t_{1/2} = \frac{0.693}{k(p_s^C/c_s^{D,\infty})} \quad (5)$$

[4] The form of equation (1) is suggested by the data in Figure 4.

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indicating that the total time required to reach equilibrium will be directly proportional to the final solute concentration in D, and inversely proportional to k and to the equilibrium partial pressure of the solute. The constant k should change relatively little for a variety of solutes in a given equilibrator, since diffusion coefficients are not so strongly dependent on molecular geometry and functionality as are vapor pressures and solubilities. Thus, the rate of transfer of a slightly volatile solute would not be prohibitively slow if the ratio $p_s^C/c_s^{D,\infty}$ (i.e., the Henry's law constant) were sufficiently large. The approximate relation

$$\frac{t_{1/2}\,(\text{solute X})}{t_{1/2}(\text{water})} = \frac{K_H\,(\text{water})}{K_H\,(\text{solute X})} \qquad (6)$$

where K_H(water) and K_H(solute X) are the Henry's law constants for water and solute X, should be useful in predicting whether or not the present technique would be suitable for equilibrations with a given solute-solvent system.

Equilibrators such as those described here were used to demonstrate that water exists primarily as the monomer in benzene and CCl_4 solutions.[5]

[5] Christian, S. D., Affsprung, H. E., and Johnson, J. R. *J. Chem. Soc.*, 1963, 1896.

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Moscow

A Simple Kinetics Experiment

For general chemistry laboratory

Simple experiments illustrating basic facts are needed in undergraduate chemistry. An experiment is proposed which requires no elaborate equipment. The time required for this experiment is about 45 minutes for preparation and three hours for following the reaction.

Since potassium peroxodisulfate is a very strong oxidizing agent (oxidation potential = −2.01 v)[1] it can oxidize a variety of inorganic ions as well as certain organic compounds. It has been found by Bacon and Doggart[2] that, in the presence of catalytic amounts of silver ion, peroxodisulfate ion will oxidize benzoic acid to a resinous product. The method of measuring the rate of this reaction was by an iodometric titration of the remaining peroxodisulfate.

Certain inorganic ions cannot be used since their oxidized state can be reduced by iodide ion which is used in the determination of peroxodisulfate ion. The resinous product formed from the reaction of benzoic acid does not interfere with the analytical determination.

The reaction rate was found to be dependent on the concentration of two species, peroxodisulfate ion and silver ion. The rate was independent of the concentration of the reducing agent. The rate of the reaction can be expressed as follows:

$$\frac{d[S_2O_8^{2-}]}{dt} = k[S_2O_8^{2-}][Ag^+] \qquad (1)$$

Since silver ion is present only as a catalyst its concentration remains constant in any particular reaction. The reaction, then, is first order with respect to the peroxodisulfate ion concentration. Then by integrating the result, equation (2) is obtained.

$$\frac{1}{[Ag^+]} \ln \frac{[S_2O_8^{2-}]\text{ initial}}{[S_2O_8^{2-}]} = kt \qquad (2)$$

The Experiment

In the absence of a catalyst the reaction rate of the peroxodisulfate ion is very slow. Allen[3] has found that uncatalyzed peroxodisulfate has a half-reaction time of 20 days at 40 °C in a reaction which is independent of the concentration of the reducing agent.

A solution was made which was 0.01 M with respect to both benzoic acid and peroxodisulfate ion. To this was added enough silver nitrate solution to make the solution 0.001 M with respect to silver ion. The reaction mixture was placed in a constant temperature bath at 35 °C. Aliquots were withdrawn and were determined iodometrically by the method of Kolthoff and Carr.[4] The liberated iodine was titrated with standard thiosulfate using starch as an indicator. The figure shows a typical first-order plot of the data; k calculated from the slope is 1.41 min^{-1}, $t^1/_2$ = 492 min.

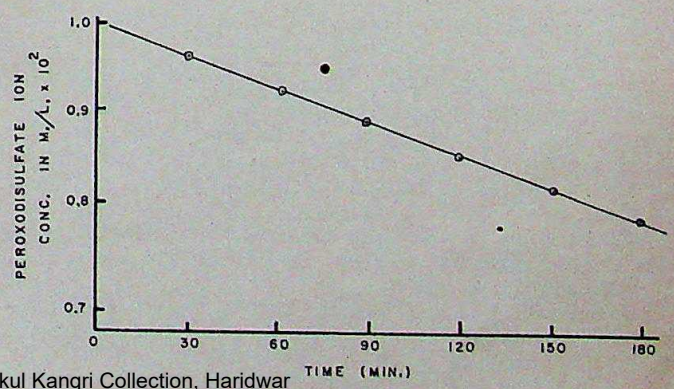
Concentrations of catalyst between 0.0005 M and 0.0015 M may be used. Students' data should be within 5% error.

[1] Latimer, W. M., "Oxidation Potentials," 2nd ed., Prentice-Hall, Inc., New York, 1952, p. 78.

[2] Bacon, R. G. R., and Doggart, J. R., *J. Chem. Soc.*, 1960, 1332–8.

[3] Allen, T. L., *J. Am. Chem. Soc.*, 73, 3589 (1951).

[4] Kolthoff, I. M., and Carr, E. M., *Anal. Chem.*, 25, 298 (1953).



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Semimicro Modification of the Rast Method for Determining Molecular Weights

In the course of research involving small-scale organic syntheses, we have experienced the need for a method of determining molecular weights which might be suitable for the undergraduate organic or physical chemistry laboratory but would eliminate some of the drawbacks of the usual methods. For example, the Beckmann procedure[2] involves the inconveniences of the thermometer itself and requires relatively large samples, the micro Rast method[3] requires the accurate weighing of very small samples and the forcing of waxy camphor through small-bore tubing, and the usual macro Rast method[4] requires large samples and permits loss of camphor through sublimation during the mixing process. We have obtained satisfactory results with the relatively simple semimicro Rast procedure described below.

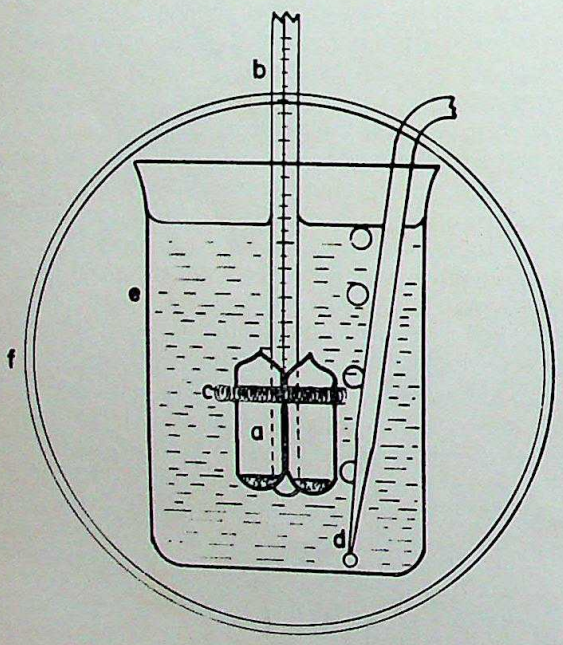

Figure 1. Molecular weight apparatus.

Camphor, chosen as a solvent because of its high freezing point depression constant and its ability to form homogeneous solutions with the type of aromatic compounds being studied, was sublimed and stored in glass-stoppered weighing bottles. A 10- × 75-mm Pyrex test tube, to be used for the melting point tube, was weighed to the nearest tenth of a milligram on a chainomatic balance. Five to 15 mg of powdered sample was picked up in a melting-point capillary tube, the outside of the capillary was brushed off, and the sample was pushed out of the capillary into the bottom of the test tube by means of a fine glass rod in such a way as to leave no solid adhering to the walls of the test tube. The test tube was reweighed, and enough small lumps of camphor to form a 5–15% solution of "unknown" was carefully placed in the bottom of the test tube by means of a nickel spatula. The tube was reweighed. In a second, unweighed test tube about the same amount of camphor was placed, to be used for determining the melting point of the pure solvent.

Each test tube was sealed with an oxygen-natural gas torch as follows: The closed end of the tube was wrapped with a strip of wet paper toweling to prevent heating and sublimation of the sample. Approximately 3 cm above the sample, the tube was heated with a

Table 1. Results of Molecular Weight Determinations

Compound	Formula Wt.	Wt. Solute (mg)	Wt. Solvent (mg)	ΔT(°C)	K_f	Mol. Wt. Exp.	Mol. Wt. Beckmann Method[2]
Determination of the melting point depression constant							
Biphenyl	154.2	8.7	93.1	25.25	41.6	...	...
Acetanilide	135.2	4.7	76.9	18.5	40.8	...	...
Benzoic acid	122.1	12.3	124.6	32.5	40.2	...	...
				Av.	40.9[a]		
Results with semimicro apparatus							
Naphthalene	128.2	18.1	167.1	33.5	...	132	125
Biphenyl[b]	154.2	15.2	147.2	27.0	...	156	151
Maleic anhydride[b]	98.1	11.3	99.5	44.0	...	106	...
Synthetic product							
Trial 1	332[c]	9.7	148.3	7.0	...	382	...
Trial 2	332[c]	8.5	142.4	6.5	...	375	...

[a] This value compares favorably with that reported by Meldrum, W. B., Saxer, L. P., and Jones, T. O., *J. Am. Chem. Soc.*, 65, 2023 (1943) who suggest a value of about 39.7 for solutions of concentrations greater than 0.2 molal.

[b] This was handed out as an unknown in physical chemistry or organic qualitative analysis and was not identified until after the molecular weight had been determined.

[c] This is thought to be a polymer of a compound of molecular weight 166 or 168.

[1] 1961–63 National Science Foundation Undergraduate Research Participation Program participant.

[2] Daniels, F., Mathews, J. H., Williams, J. W., Bender, P., Murphy, G. W., and Alberty, R. H., "Experimental Physical Chemistry," 4th ed., McGraw-Hill Book Co., Inc., New York, 1949, pp. 84–6.

[3] Cheronis, N. D., and Entrikin, J. B., "Semimicro Quantitative Organic Analysis," 2nd ed., Interscience Publishers, Inc., New York, 1958, pp. 147–8.

[4] Shriner, R. L., and Fuson, R. C., "The Systematic Identification of Organic Compounds," 3rd ed., John Wiley and Sons, Inc., New York, 1948, pp. 50–1.

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small, hot flame and drawn out to a diameter of about 4 mm. After cooling somewhat, the constriction was heated sufficiently to complete the seal.

Figure 1 shows the sealed tubes (*a*) attached to a 360° thermometer (*b*) by means of a coil spring (*c*). Various types of Thiele tubes were tried as melting-point baths, but were discarded in favor of a 150-ml beaker (*e*) filled with glycerol. The bath was heated with a microburner bearing a chimney, and was stirred with a carefully regulated stream of compressed air (*d*). A large magnifying glass (*f*) aided the observation of the samples.

The mixture was alternately melted and solidified until homogeneity was achieved. Melting points of both the camphor and the mixture were read within 0.25°C. The standard equation for this type of determination was used:

$$\text{Molecular weight} = 1000\, K_f g/(G\Delta T)$$

where K_f = melting point depression constant (40.9), g = solute weight, G = solvent weight, and ΔT = depression of melting point.

Table 1 shows some results obtained by undergraduate students.

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High Pressure Techniques for Microscale Reactions

In recent years great advances have been made in microscale analytical techniques. These techniques as well as the high cost of laboratory equipment and chemicals have made the use of microscale reactions both practical and economically necessary. Laboratory equipment exists for (10 g scale) ordinary organic reactions but no suitable equipment or techniques are available for very small high pressure reactions. We have therefore had occasion to develop high pressure techniques for microscale organic synthesis studies. These procedures were developed with a particular interest in obtaining complete material balances and in utilizing only inert construction materials. This paper outlines the design criteria and gives specific examples of pressure vessels which have been designed and tested.

Pressure vessels constructed of glass are not new to chemists. Heavy walled glass tubes sealed at one end and drawn out to a fusible tip at the other (Carius tubes), have been used for many years as small scale laboratory autoclaves. There are, however, several drawbacks to these Carius tubes. The seal where the tube is fused cannot be annealed and so may crack under stress. The opening of such tubes with a glass cutter is a difficult and sometimes dangerous operation. In addition there are problems in transferring materials out of contact with air.

Simple glass bodied Teflon valves have recently become available from laboratory supply houses.[1] These valves can be used as closures on Pyrex pressure vessels as well as valves to control the flow of material into the reactor. Nonvolatile materials can be placed in the reactor by completely unscrewing the stem of the valve and injecting the material in with a hypodermic syringe. Volatile materials can be transferred into the reactor after evacuation, simply by cooling.

Design of Glass Reactors

The maximum gas pressure which the valve shown in Figure 1 will withstand will depend upon whether the pressure is applied to the stem side or the seat side (when the valve is closed). The maximum seat pressure P_1, is equal to the maximum force which the stem threads will withstand divided by the area of the closed seal. (The seat diameter of the glass valves previously referred to are either $1^1/_4$ mm or 4 mm.)

$$P_1 = \frac{4F}{\pi D_1^2} = 2100 \text{ psig (for } F = 4 \text{ lb, } D_1 = 1.25 \text{ mm)}$$
$$= 205 \text{ psig (for } F = 4 \text{ lb, } D_1 = 4 \text{ mm)}$$

A value for F of four pounds was experimentally determined as a safe working force by loading the valve stems with sufficient weights to tear out the threads. In addition, the large and small diameter valves have been tested at their working pressures numerous times without failure. Valves could be designed which would have stronger threads and a thicker body. These valves would, however, have to be custom made.

The maximum pressure which the stem side of the valve can stand is P_2 or 4 pounds, divided by the sectional area of the stem. This is approximately 80 psig for a 5 mm diameter stem. Thus, when the $1^1/_4$ mm valve is closed it can hold back several thousand pounds, yet when it is open the maximum working

This research was supported by the Advanced Research Projects Agency, Propellant Chemistry Office, and was monitored by Army Ordnance under Contract No. DA-30-069-ORD-2487.

[1] Fisher Porter Valve Catalogue no. 795-609.

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pressure is only 80 psig.

The pressure limits of the glass valves can be clearly seen. There remains, however, the specification of the dimensions of the vessel to which the valve is attached. Figure 2 shows a section of wall of a cylindrical pressure vessel. The pressure against the inside of this section is balanced by the tension in the wall. Using a maximum allowable tension in the glass of 10,000 psi (70°F) the maximum pressure containable is given by the relationship below.

$$P_1 = 10{,}000 \left(\frac{t}{R}\right)$$

Where t is wall thickness and R is radius, both t and R should have the same units. Pressure P_1 (psig) will be less for temperatures higher than 70°F.

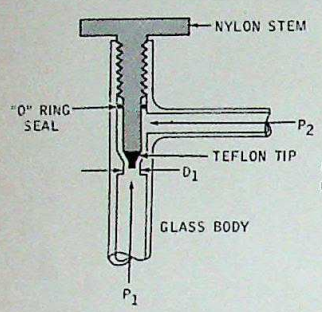


Figure 1.

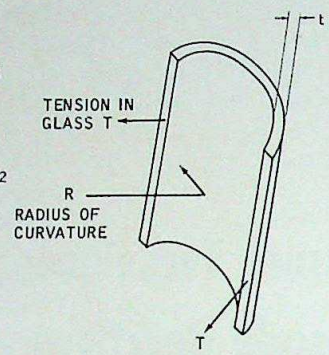


Figure 2.

Testing of Glass Vessels

The types of glass pressure reactors which were built and tested were all of the same general design, i.e., cylindrical body with one or two 1-cm diameter heavy walled inlet tubes attached (Figure 3). In some cases the valves were blown onto the inlet tubes of the reactor before annealing. In other cases, the valves were attached after annealing of the reactor, so that a Teflon coated magnetic stirrer could be inserted. In this case the junction between the valve and the extension tube from the reactor was flame annealed after joining.

Reactor bodies of 4-cm diameter, 11-cm length, and wall thickness 0.4-cm were checked at 950 psig by condensing in an excess of CO_2 using liquid nitrogen and allowing the reactor to warm to room temperature. No leakage was experienced. Reactors of 2-cm diameter and 0.3-cm wall thickness have been regularly used at 200°C and 800 psig with no difficulty. The 0.125-cm seat diameter valves were used in both these cases.

Metal Vessels

Pressure vessels analogous to the previously described glass ones have been constructed of stainless steel using high pressure unions and valves (Fig. 3). These vessels are relatively leak free providing care is taken in assembling the systems.

In general the stainless systems were used only for reactions where the glass would be attacked by the reactants, where the reaction conditions were too severe for glass, or where reactants had to be charged at high pressure. The virtues of glass, i.e., freedom from leaks, cleanliness, and ability to see the reaction make it the preferred construction material for most reactions.

Shielding of Reactors

The types of shielding devices used for pressure reactors can be divided into two classes, those that shield from blast (pressure release or detonation) alone and those that shield from blast and noise.

A suitable shield from blast alone would consist of a section of 4-in. diameter schedule 80 stainless steel pipe, or a 4-in. diameter rectangular box made of $^1/_4$-in. steel plate. A window of 1-in. thick Plexiglass could be attached by screws inside a slit cut in the pipe or box. Providing the window slit in the steel does not run more than one-half the length of the shield, such a device has been tested to contain a detonation of 4 g of metal-encased high explosive centered in the shield.

A suitable noise and fragment shield (Fig. 4) has been constructed from a 55-gallon oil drum. The reactor to be shielded is placed inside a pail containing a Dewar flask for liquid nitrogen, suitable thermocouples and a heating element. The pail is sealed with tape and buried close to the bottom of the drum under 1.5 feet of coarse gravel or rock salt. The feed lines and valve handles extend through the packing. Volatile material can be transferred into the reactor after evacuation simply by pouring liquid nitrogen through a feed line into the buried Dewar. The liquid nitrogen is vaporized and temperature of the reaction controlled by the heating element and thermocouples surrounding the reactor. Volatile products can be removed through the feed line. The noise level next to such a packed shield is almost zero when 6 grams of high explosive are detonated inside the pail.

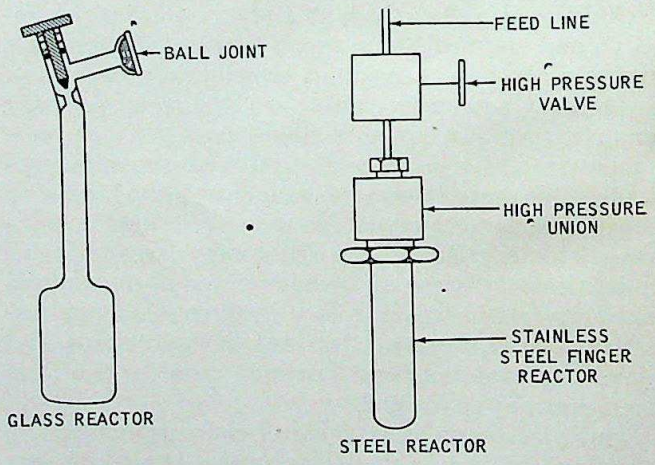
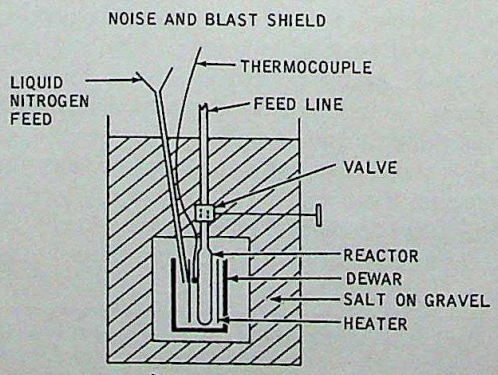


Figure 3.



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A Small Fluidized-Solid Constant Temperature Bath

This note describes the construction and operation of a small (2 in. × 16 in.) constant temperature bath in which a fluidized solid is the heat-transfer medium.

Most laboratories are equipped with constant temperature baths in which a liquid or vapor is the heat transfer medium. The flexibility of such heating baths is obviously limited by boiling point and by thermal and oxidative stability of the liquids. Wood's metal, Dowtherm, or molten salt baths are used to attain temperatures above 300°C, but these materials are inconvenient for small baths and present considerable safety hazards.

Fluidized solids beds have been used as constant temperature baths. Adams, Gernand, and Kimberlin[1] have described a relatively large apparatus (about 6 in. × 36 in.) in which a fluidized bed of inert solid was used as a constant temperature bath. Adams, *et al.*, included in their publication an excellent review of the literature. They also described the principles and mechanics of operation of fluidized beds of solids. Manes and Chalmers[2] used a 2-in. × 30-in. glass apparatus in which 80–200 mesh silica gel was fluidized at 300°C (±2°) by passage of 360 l/hr of laboratory air.

Our apparatus is much smaller and more compact than the equipment already described.[1,2] In addition, the apparatus does not require an external source of compressed air. The small size of the equipment makes it more useful for laboratory work in which small vessels must be heated at a constant temperature.

The fluidizer was constructed from standard wall borosilicate glass tubing. A fritted glass disc (51 mm diameter, porosity "C" (40–60 micron), Corning) was sealed 1 in. from the bottom of a piece of $2^1/_4$-in. od glass tubing, 11 in. long. The bottom was rounded and a hose connection sealed to the center of the bottom.

The heater consists of a piece of $2^3/_4$-in. glass tubing, $9^1/_2$ in. long, fire polished on both ends, wrapped with $14^1/_2$ ft of Trophet A (W. B. Driver Co.) resistance wire, size $^1/_{16}$ in. × 0.0063 in. (1.370 ohms per ft). The heater was rated at approximately 650 watts at 110 v. A protective jacket of $3^1/_4$-in. od glass tubing $10^1/_4$ in. long was placed around both the heating jacket and fluidizer.

The whole assembly (the fluidizer, heating jacket, and outside jacket) was mounted on a 6-in. × 5-in. × 4-in. aluminum chassis. In the chassis two aquarium type aerators were mounted. The aerators were connected in parallel and the output connected to the hose connection on the bottom of the fluidizer. Figure 1 shows construction details. Figure 2 is a photograph of the apparatus. The bottom panel has been removed to show arrangement of the pumps in the bottom part of the unit.

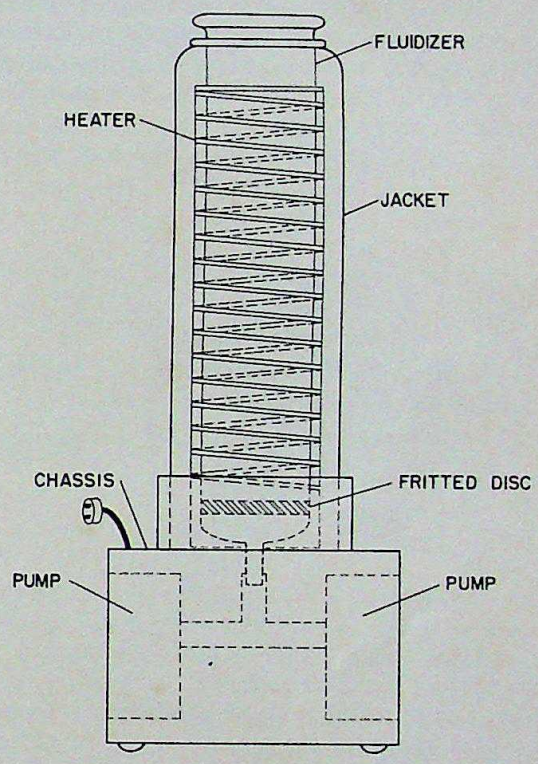

Figure 1. Construction details of the apparatus.

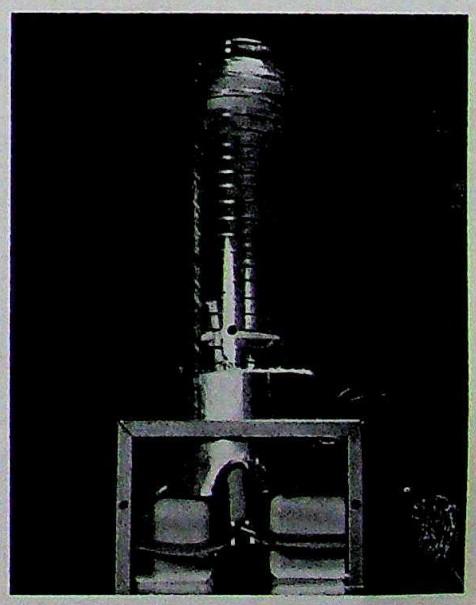

Figure 2. Photograph of the apparatus.

[1] Adams, C. E., Gernand, M. O., and Kimberlin, C. N., Jr. *Ind. Eng. Chem.*, **46**, 2458–2460 (1954).
[2] Manes, M., and Chalmers, D. G, J. Chem. Educ., **38**, 102 (1961).

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The pumps produce air flows of 12–22 l/hr through the empty apparatus when operated at 60–80 v. When a $3^1/_2$-in. bed of silica-alumina microspheres (Davison F-1, 25 silica-alumina, average particle size 65 microns) is placed in the apparatus, flows of 2–20 l/hr at 25°C are obtained when the pumps are operated at 60–110 v. Optimum fluidization and mixing of solid are obtained at 90–100 v. (12.5–16.5 l/hr). Fluidized bed height is 4 in. The bed can be heated easily to 250°C in 15 minutes. Rate of heating obviously depends on wattage of the heater. Temperature was controlled by plugging a Powerstat into a West JS-1 Gardsman controller. Temperature control is excellent; a variation of ±3°C is easily achieved. By careful setting of the Powerstat, equally good control can be realized without the Gardsman controller. Temperature within the bed is essentially constant at any given time, regardless of the position of the temperature sensing thermocouple.

With a $3^1/_2$- × 4-in. bed of solids, the pumps produce 12–19 l/hr flow at 200–350°C. This flow is optimum for fluidization and mixing. The flow pattern of solid can be seen easily if a little dark colored solid is added. Flow of solid is upward in the center of the bed, and downward at the sides, much like convection currents. The linear rate of flow of solid particles is 8–10 in. per minute.

Flow rates were measured as follows: A rubber stopper was placed in the top of the bath. A T-tube led to a filter and then to an orifice flow meter. Very little solid was carried into the filter. When a vessel, such as a test tube, was heated in the bath, the thermocouple was placed near the bottom of the test tube. A piece of aluminum foil was crimped around the top of the bath and around the test tube. This simple closure prevented significant losses of solid to the air.

Several other solids were evaluated because they have higher specific heats than silica-alumina. Carbon, 80 mesh, was satisfactory, but 200 mesh was not. Carbon would obviously be useful only at moderate temperatures. Fine sand, 40–80 mesh, was not fluidized. A mixture of sand and Davison F-1 microspheres was mediocre. Carborundum, 90 mesh, mixed with the microspheres, was poor; 320 mesh Carborundum and the microspheres was mediocre.

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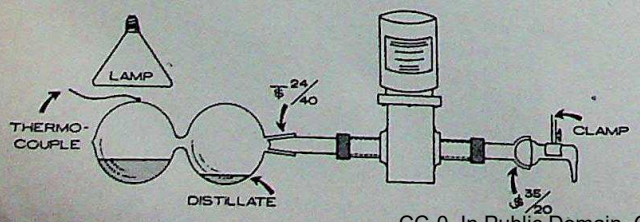
Apparatus for Molecular Distillation and Vacuum Sublimation

A simple, inexpensive, yet highly effective apparatus for laboratory scale purifications by molecular distillation or vacuum sublimation has been designed. The apparatus illustrated eliminates spattering due to residual traces of solvent or to superheating, and minimizes exposure of the material to high temperatures since the heat is applied only to a thin film of the liquid.

Quantities of material from 0.5 ml to 300 ml have been distilled using "hour-glass" flasks varying in size from 25 to 1000 ml. Larger flasks and quantities can also be used; however, these require some support at the constriction of the two flasks.

We have found the Buchler Rotoevaporator Model PFE-1A to be a very convenient rotating device (as illustrated). The degree of vacuum attainable is limited only by the seal at the rotating joint. Using Apiezon Grease N, we have been able to evacuate the rotating system to 10–20 microns. By the use of other more expensive sealed rotational systems, a lower vacuum could certainly be produced. The hour-glass flask can be used with other types of rotary evaporators (Rinco, Labline, Buchi, etc.); however, we found it difficult to obtain high vacuums with these.



In use, the material to be distilled is put into the bottom flask using a long-stemmed funnel. The apparatus is then assembled as illustrated; the flasks may be horizontal or sloped (left end raised slightly). Heat is conveniently applied by means of a heat or quartz lamp[1] and may be regulated by varying the distance from the flask. The temperature may be roughly measured by laying a thermocouple on top of the rotating flask. The flask may also be heated by means of an oil or steam bath, where prolonged direct heating of the material is not harmful.

The condenser flask may be cooled by a stream of running water or an ice bath if air cooling is not sufficient. At the end of the distillation, the distillate can be removed using a long, bent dropper or pipet.

In addition to its use for the distillation of very high boiling substances, this apparatus is convenient for rapid purification by distillation of solvents and liquid reagents using a water aspirator as the source of vacuum. The apparatus is also useful for sublimation of large quantities of solid material. When used for this purpose, the sublimate can either be scraped out of the condenser flask or dissolved and removed with a bent pipet.

[1] Another convenient heat source is a heat gun similar to Cole Parmer's #3024 which emits heating up to 350°C.

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Simple Evaporator for Heat Sensitive Compounds

The need for complete removal of eluting solvents from labile chromatographic fractions led to the fabrication of the simple evaporation apparatus here described. Essentially it is a device for: increasing the available liquid surface from which volatile molecules can escape, increasing the flow of heat to the evaporating surface, and providing for operation at a reduced pressure to facilitate the vaporization of solvents at relatively low temperatures.

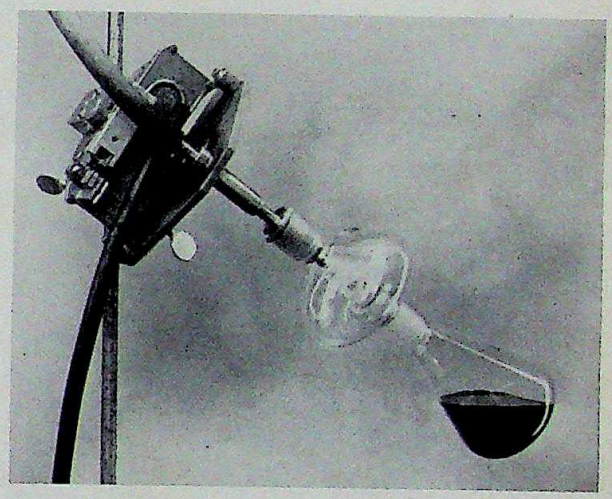
In these respects it is similar to flask rotating devices recently described in the literature[1–6] or available commercially. The novel features of this device are the use of an inexpensive windshield-wiper motor to provide an oscillatory rotational force, and the elimination of rotating vacuum seals. The device is inherently explosion-proof because it operates from the laboratory vacuum system.

The apparatus is illustrated in the photograph. The automobile-type windshield-wiper motor is mounted on a $^1/_4$-in. thick steel plate using the motor mounting holes provided. A $^1/_8$-in. thick brass gear having 80 teeth (pitch diameter $2^1/_2$ in.) is mounted on a stub shaft attached to the steel plate directly opposite the end of the motor shaft. A pin in the hub of this gear connects with the crank supplied on the end of the motor shaft. A second gear, which has 32 teeth, is attached to a 6-in. long, $^3/_8$-in. diameter stainless steel tube at a point approximately $1^1/_2$ in. from the upper end. This tube rotates in $1^1/_2$ in. long bronze bearing which is pressed into the steel plate. A small collar on the tube at the lower end of the bearing keeps the tube in position.

An early version used a simple rubber stopper at the lower end of the tube for attaching Erlenmeyer flasks. In later units the rubber stopper was replaced by a stainless steel 24/40 standard taper male joint soldered on the tube. A $^1/_8$-in. wide groove located $^3/_{16}$ in. from the larger end of the standard taper is machined to a diameter of $^3/_4$ in. for a size 14 O-ring. The upper end of the metal tube is connected through the usual dry ice or liquid air traps to a vacuum pump via elastic tubing. Rubber or plastic tubing permit flask rotation of 300° or more virtually without hindrance.

In some operations the use of a trap immediately above the evaporation flask has been helpful, especially for liquids that froth excessively. A glass trap which rotates with the flask is shown also in the photograph.

The vacuum motor shaft operates through a sector of approximately 120°. Using the gears described, the resultant flask rotation is 300°, which has proved to be very satisfactory for distributing a film of liquid on the surface of the evaporation flask.



A 6-in. long by $^1/_2$-in. diameter steel rod is fastened to the mounting plate at a right angle to the axis of rotation and parallel to a line connecting the gear centers. This arrangement allows the entire assembly to be supported in a regular laboratory rod clamp and permits selecting or changing the axis of rotation (with respect to horizontal) at any time. This feature has proved to be especially convenient. The application of heat to the flask, if required, is accomplished in the usual manner: i.e., by rotating the flask in a water bath or by means of a heat lamp.

The apparatus can be constructed at a very nominal cost since no rotating seal is used. For the rubber stopper model no precision machining is required. The vacuum motor operates directly off the laboratory vacuum line. The largest single material item is the vacuum motor which can be purchased for approximately $8.75.

[1] Craig, L. C., Gregory, J. D., and Hausmann, W., *Anal. Chem.*, **22**, 1462 (1950).
[2] Partridge, S. M., *J. Sci. Instr.*, **28**, 28 (1951).
[3] Volk, E., *Anal. Chem.*, **27**, 1207 (1955).
[4] Greef, F., and Larsen, C., J. Chem. Educ., **33**, 556 (1956).
[5] Arnett, E. A., J. Chem. Educ., **37**, 247 (1960).
[6] Carleton, R. O., J. Chem. Educ., **39**, 256 (1962).

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Vacuum and Controlled Atmosphere Differential Thermal Analysis Apparatus

Although a number of differential thermal analysis (DTA) units have been described in THIS JOURNAL (*1–3*) and elsewhere (*4–6*), there is a definite need for a simple apparatus which will allow the determination of the DTA thermogram of a substance under conditions of vacuum, or controlled atmospheres other than air. The recent excellent review by Gordon (*7*) shows that this type of apparatus is available commercially but that they are all fairly expensive ($7000 to $10,000). This article describes a simple apparatus which can be assembled easily and can be used under conditions of vacuum or controlled atmospheres from ambient temperature up to 1000°C.

The furnace and sample holder is schematically illustrated in Figure 1.

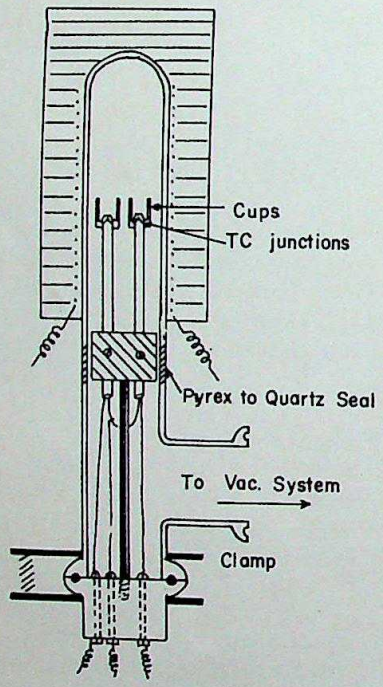

Figure 1. Schematic illustration of DTA furnace and sample holder.

The furnace and sample holder were essentially similar to that described by Lodding and Hammell (*8*). The furnace tube was 19 cm long and 2.5 cm diameter and was constructed partly of quartz. The lower end of the tube contained two Pyrex glass "O" ring joints, 25 mm id, which was attached to the quartz tube by a quartz-to-Pyrex graded seal. The lower "O" ring joint was enclosed by a nylon seal, machined to dimensions identical to that of the glass "O" ring joint and attached to it by a clamp. Provision was made for electrical connections through the seal by use of small bolts, sealed on the outside by Apiezon "Q" wax. The Chromel-Alumel thermocouple wires were brought into the furnace zone by means of 3.0 mm diameter two-holed ceramic insulating tubing. The sample and reference cups were made of Inconel, 7 mm diameter and 10 mm long, obtained from the Robert L. Stone Co., Austin, Tex. The cups fit snuggly on the insulator tube and were in intimate contact with the thermocouple junctions.

Construction of the furnace heating element and furnace temperature controller was the same as previously described (*3*).

Connection of the furnace and sample holder to the vacuum system is illustrated in Figure 2. It was attached to the system through the "O" ring joint and clamp to provide a vacuum tight seal. Provision was also made for the sampling of the decomposition gases by use of the glass bulb, *G*, attached to the system by a standard taper glass joint. The gas content of the bulb could be analyzed by use of either a gas chromatograph or a mass spectrometer. To operate the unit under a static gas atmosphere other than air, the system was evacuated, then filled with the desired gas through stopcock *S*. For vacuum studies, the system could be continuously evacuated during the heating cycle.

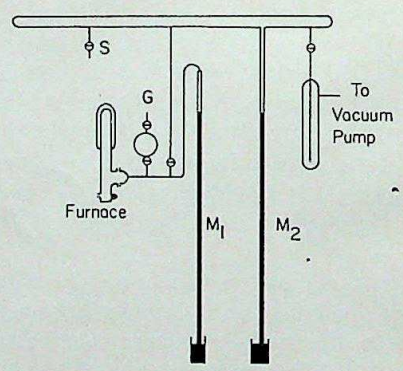

Figure 2. Schematic illustration of vacuum system.

The differential thermocouple signal was amplified by use of a Leeds and Northrup microvolt dc amplifier, Model No. 9835-B, and then recorded on the *y*-axis of a Houston Instruments, Model HR-95, X-Y recorder. The temperature of the furnace, as monitored by the reference thermocouple, was recorded on the *x*-axis.

The use of the apparatus, under conditions of vacuum and static air atmospheres, is illustrated in Figures 3 and 4.

Results from two types of compounds are illustrated. The first type is one in which the thermal dissociation reaction evolves a volatile substance and hence is pressure dependent. The second type is a compound which undergoes a phase transition and is not pressure dependent under the conditions described here. Two

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compounds of the first type are illustrated: they are $CuSO_4 \cdot 5H_2O$ and $Cu(NH_4)_2(SO_4)_2 \cdot 6H_2O$.

The DTA thermogram for $CuSO_4 \cdot 5H_2O$, in air, has previously been described and the thermal transition assigned (*9, 10*). The curve for $CuSO_4 \cdot 5H_2O$ obtained with this apparatus is similar to that previously described (*9*) except that the peak temperature maximas are all shifted to slightly higher temperatures. Maximum peak temperatures obtained were at 130, 170, 280, 755, and 850 °C, respectively. The first three peaks are due to the evolution of hydrate-bound water while the last two are caused by the dissociation of the anhydrous $CuSO_4$ to give a residue of CuO.

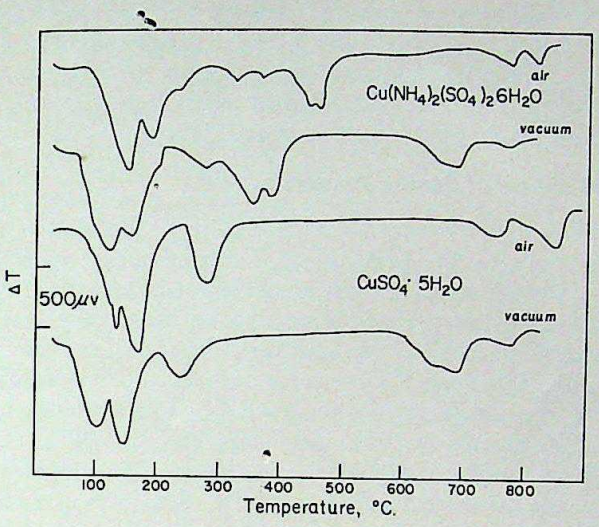

Figure 3. DTA thermograms under static air (680 mm Hg) and vacuum (~1 mm Hg) atmospheres. Heating rate 10 °C min^{-1}.

The DTA curve for $CuSO_4 \cdot 5H_2O$, in vacuum, is similar to that obtained in air except that the peak temperatures are somewhat lower and there is a little better resolution of the peaks. Peak temperatures were 100, 145, 240, 685, and 780 °C, respectively. There is a different mechanism operative for the dissociation of the anhydrous $CuSO_4$ because the residue was Cu_2O instead of CuO, as was found in air. The Cu_2O was identified by X-ray powder diffraction of the residue. Apparently, the CuO that is formed by the reactions:

$$2CuSO_4 \rightarrow CuO \cdot CuSO_4 + SO_3$$

and

$$CuO \cdot CuSO_4 \rightarrow 2CuO + SO_3$$

is reduced by the SO_2 formed by the equilibrium:

$$SO_3 \rightleftarrows SO_2 + {}^1/_2O_2$$

because CuO does not evolve oxygen under the above experimental conditions.

The two curves for $Cu(NH_4)_2(SO_4)_2 \cdot 6H_2O$ illustrate essentially the same type of behavior between air and vacuum atmospheres. In vacuum, the peaks were shifted to lower temperatures with a slight increase in resolution of the peaks. This was quite pronounced for the evolution of $(NH_4)_2SO_4$ from the compound in vacuum. Two peaks were observed, at 355 and 390 °C, respectively, while in air, there was only a peak and shoulder peak at about 450 °C. Again, the decomposition of $CuSO_4$ in vacuum gave Cu_2O; while in air, CuO was formed.

The thermograms for sodium nitrate, as illustrated in Figure 4, show that the peak maxima temperatures are not changed by the use of different atmospheres. The first peak, at about 280 °C, is a crystalline phase transition which has previously been described by Kracek (*11*) and others (*12*). Accurate measurements give the transition temperature as 275.5 °C. The second peak, beginning at 300 °C, is that due to the fusion of the compound. The reported melting point of sodium nitrate is 306.8 °C (*13*).

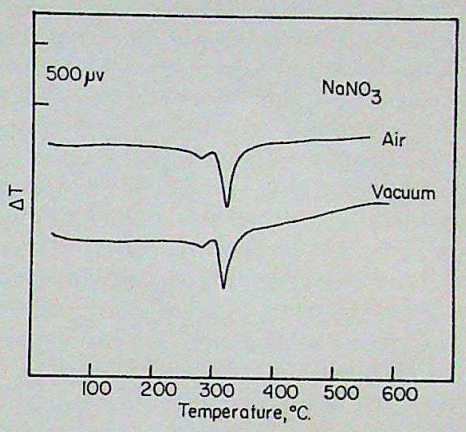

Figure 4. DTA thermograms under static air (680 mm Hg) and vacuum (1 mm Hg) atmospheres.

The variable furnace atmosphere inherently increases the applications to which the technique of DTA may be applied. Not only can oxygen or moisture sensitive substances be studied but by controlling the pressure, heats of sublimation (*14*) as well as other heats of dissociation data can be obtained.

Acknowledgment. This work was sponsored by the Robert M. Welch Foundation of Houston, Texas. The glass fabrication ability of Fred Kennedy of Texas Instru-ments, Inc., is gratefully acknowledged.

Literature Cited

(1) Borchardt, H. J., J. Chem. Educ., **33**, 103 (1956).
(2) Wendlandt, W. W., J. Chem. Educ., **37**, 94 (1960).
(3) Wendlandt, W. W., J. Chem. Educ., **38**, 571 (1961).
(4) Smothers, W. J., and Chiang, Y., "Differential Thermal Analysis," Chemical Publishing Co., New York, 1958.
(5) Kissinger, H. E., and Newman, S. B., in "Analytical Chemistry of Polymers," G. M. Kline, ed., Interscience Publishers, New York, 1962, Vol. 12, part 2, chap. 4.
(6) Wendlandt, W. W., in "Techniques of Inorganic Chemistry," H. B. Jonassen, ed., Interscience Publishers, to be published in 1963.
(7) Gordon, S., J. Chem. Educ., **40**, A87 (1963).
(8) Lodding, W., and Hammell, L., *Rev. Scient. Instru.*, **30**, 885 (1959).
(9) Borchardt, H. J., and Daniels, F., *J. Phys. Chem.*, **61**, 917 (1957).
(10) Reisman, A., and Karlek, J., *J. Am. Chem. Soc.*, **80**, 6500 (1958).
(11) Kracek, F. C., *J. Phys. Chem.*, **34**, 225 (1930).
(12) McLaren, A. C., *Rev. Pure Appl. Chem.* **12**, 54 (1962).
(13) Hodgman, C. D., "Handbook of Chemistry and Physics," 44th ed., The Chemical Rubber Publishing Co., Cleveland, 1962, p. 656.
(14) Markowitz, M. M., and Boryta, D. A., *J. Phys. Chem.*, **66**, 1477 (1962).

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Using Russian Technical Information

Scientists in this country paid little attention to the Russian scientific literature and held uninformed opinions of it, until recent continued successes in space and some other fields convincingly demonstrated the potential importance of their publications to science and technology. Even now, few American scientists can benefit from them. Only 1.6% can read Russian (*10*), and it is hard enough to keep up with information published in English.

Familiar agencies have tried to help the harassed researcher. Chemical Abstracts and, in the petroleum field, the American Petroleum Institutes' "Abstracts of Refining Literature" promptly report on new research done all over the world. The Office of Technical Services and other public and private organizations provide translations of selected Russian papers, but abstracts can not accomplish the meeting of minds that results from study of original papers, particularly the introductory parts that reveal the motivation of research, and the discussions and references that contribute to evaluating it. Coverage by translations is also incomplete, especially for older Russian literature.

Because the Soviet economy differs so much from ours, evaluating Russian research is not easy. New approaches to assimilate their literature can be helpful.

Environment of Soviet Research

The Soviet state supports all basic and applied research. It is the duty of scientists to work tirelessly for the utilization of their results. For this reason, almost all successful technically trained people have more than one assignment; every important researcher is teaching, and every important person in academic life is also a consultant in industry. Research institutes that do not maintain effective contacts with industry are scorned (*14a*), and speedier utilization of research is frequently demanded (*14*).

Partly as the result of emphasis upon applications, the Soviet planned economy has expanded rapidly. Production and refining of oil, for example, have been organized to take advantage of techniques developed in the United States. Annual production of oil passed one billion barrels in 1960, and has exceeded 40% of ours. Research in oil refining has advanced to the point where problems and methods of attacking them are similar to ours. A large expansion of petrochemicals is under way. Although consumer goods now receive more attention than they did previously, capital goods and heavy industry are still favored. Quality of goods is often sacrificed to meet quantity objectives.

Research conducted in the Soviet environment resembles that in the United States in its emphasis upon applications. But the differences are just as significant. Overcoming shortages of raw materials and making commodities rather than buying them often leads to applied research that supplements rather than duplicates ours. Making soaps for greases by oxidizing hydrocarbons to fatty acids, for example, is a much busier field in Russia than it is here.

Publication of Soviet Research

The Soviet scientist and engineer contribute increasingly to the literature. The percentage of Russian papers in *C.A.* has gradually climbed to 14%; in the post war period the number of chemical publications and patents throughout the world has doubled, but the Russian share has more than doubled (*3*). Further increases are likely: in 1960 the USSR reportedly had 354,000 scientists (*7*); the USA had 201,000 (*10*);[2] and in 1959, the USSR awarded 108.6 thousand engineering degrees (*7a*), whereas the USA awarded 46 thousand.

Publication is all-important to the Soviet scientist for several reasons. Patents are also important but bring less prestige. The inventor usually applies for an "authorship certificate," which assigns his invention to the State organization that employs him, and which pays him, if it is used, in proportion to its profitability. Recognition of Soviet contributions in papers published abroad is regarded as a vote of confidence in their research and is a powerful motivation for prompt publication.

Since the Soviet industry operates, in a sense, as one huge concern, documents intended primarily for internal information may appear as publications. However, not everything is either published or made available, if published, to other countries. No doubt some subjects are "classified." The Russian abstracting journal "Referatinvyĭ zhurnal" comprising thirteen divisions for the different sciences, does not cover medicine, transportation, or food and agriculture (*1*). Transactions of research institutes and proceedings of scientific meetings are customarily published in books, rather than in periodicals; although they can sometimes be bought readily in Russia, not enough are printed to be sent abroad. In general, however, one can get as much information from the Russian technical literature as by visiting the USSR (*11*). Demands are sometimes made for stricter control of publication of data that may benefit the United States (*13*).

One of the most perplexing aspects of the Russian literature is the absence of business literature, or

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[2] The last given number includes only those scientists who reported to the National Register of Scientific and Technical Personnel. No comparison is made here of the qualifications of the scientists in the two countries concerned.

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"trade journals"; assaying the success of applied research becomes most difficult in consequence.

Science and engineering in the USSR is certainly subject to broad political control. Theories, programs, and conduct are affected alike. Despite the improvement of Soviet technical information facilities the busy Soviet scientist occasionally overlooks pertinent Soviet contributions (*12*). Recently, a Russian study of oxidation of cyclohexane overlooked a Soviet process which had already accomplished the objective (*5*), and two Soviet laboratories independently published the same work on polymerization of phenylacetylene in the same journal (*8*).

Following the Russian Literature

If Soviet research work occasionally duplicates, the problem of researchers elsewhere in following the Russian literature is far more serious. Shortcuts must be taken, and the few who can read Russian must help the many who cannot. But neither English abstracts of all Russian papers, nor complete translations of a few, will suffice.

One may justifiably suspect the widespread opinion that only that literature less than ten years old is really useful in chemistry and physics (*6*). The history of penicillin argues to the contrary (*4*), and older literature has led to profitable research in the USSR (*9*). Perhaps the opinion simply reflects a preference for recent journals when faced with lack of time. Nevertheless, abstracting publications and their indexes now appear to be used primarily for retrospective searches (*15*).

Translation of even a part of the Russian Literature is expensive. It is estimated that only 5% of the output of Soviet scientific and technical journals are translated into English (*3a*); only a small fraction of that now translated is bought by scientists.

Brief abstracts and occasional translations are a poor substitute for the original literature. Only in this way can the contents be critically analyzed, the contributions be identified and distinguished, and finally applied. But the better approach raises new problems of communicating the findings to others.

One method of communication that worked well two decades ago is illustrated by the "Survey of Foreign Petroleum Literature" sponsored by a group of petroleum refiners. Between 1937 and 1946, the writer systematically reported such segments of the then-modest Russian scientific literature as bore upon petroleum research in this country.[3] The service represented a significant part of the data that nourished the growing organism of knowledge in petroleum technology (*16*). Today, with larger journals and research organizations, the broadcast method is less satisfactory.

Within a single research organization, a specialist in the Russian literature can provide a dual service that more closely applies to the various areas of interest. The first makes the scientists generally aware of Soviet researches and the environment under which they are conducted. The second contributes both the new and the old information that applies to some problem of current interest. The latter service has come to be known as "information research" (*2*).

Using the findings of information research emphasizes effective communication. Personal contacts are fast and efficient, and several telephone conversations and visits a day help to define the pertinency of new documents and the direction that literature research should take. Such contacts with scientists at all supervisory levels further assure better reception of the later conventional written report. Sometimes a single document, written either individually or collaboratively, and not necessarily limited to Russian information, best serves the purpose, but probably more often a series of memoranda, covering from five to twenty-five articles, each, are preferable. They are faster, and permit separate treatment of various aspects of the subject.

The pattern for the specialist in Russian literature is therefore to cover continuously and systematically a wider area than is involved in the research program, and to report as explicitly as possible only information that is likely to be useful. Not until these steps have been taken need the expense of translation of the key documents be incurred.

Scanning the Russian Literature

These services nearly adequate today, will become less so as the level of Soviet research activity continues to rise. One new approach that has proved surprisingly successful involves preparing scientists to follow Russian contributions in their areas without actual knowledge of the language. Everyone has had the experience of studying a document in an unknown language and finding, despite the strangeness, that some information comes through. Rather than to build a knowledge of Russian from the ground up, the intent is to equip the scientist to *recognize* the value of a Russian paper.

Groups of research scientists were first familiarized with the thirty or so Russian journals in which the major contributions to the science and technology of petroleum appear. Typical papers were then analyzed to demonstrate that the presentation follows a conventional format, but that the general trends in various fields differ from those in English, and differ among themselves in Russian, as they do in English. Prominent authors and the organizations with which they are affiliated were briefly described.

The groups were then taught the mechanics of reading Russian together with enough phonetics to aid recognition. Common scientific terms were listed and pronounced to further tie down the actual similarity to English, despite the superficial differences. Finally, a bare minimum vocabulary of 50–100 common Russian words was learned, and the pattern of inflectional forms was explained.

Within the span of only ten weekly classes of somewhat more than an hour each, most of the scientists learned to scan effectively. They could survey new journals rapidly, and pick out the few papers that should be translated. With a little help, they were able to decide the borderline cases. They were most successful in the pure sciences such as organic chemistry and chemical physics, and least successful in applied fields like engineering and process economics.

Foreign Information in the Future

During the past generation, use of Russian technical information has thus passed through several stages.

[3] The entire survey is on microfilm in the Library of Congress.

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At first, it was ignored except by those who could read Russian or for an occasional paper that was reprinted in a more familiar language. For a time thereafter, one person could survey the entire literature well enough to supply the information wanted by an entire industry. Now it is becoming difficult for one person to cover the fields of interest of a single large research laboratory. In the future, either many scientists must gain a first-hand smattering of knowledge of Russian or some cheap new way of handling foreign information must be developed.

The same pattern may be applied to other languages less known and more difficult than Russian and to other fields.

Appreciation by scientists of the use of their research seems to be much the same everywhere. Reviews of Russian developments in technology often appear in United States publications. Eventually they are found there by Russian readers, and perhaps commented upon. Russian authors have never taken exception to occasional criticism of their researches but have referred to them objectively in the spirit in which they were meant.

Literature Cited

(1) Anonymous, *Vestn. Akad. Nauk SSSR*, **30**, 124 (1960).
(2) d'Ouville, E. L., Schmitkons, G. E., and Mohlman, J. W., *Special Libraries*, **49**, 427–430, (1958); *Petroleum Refiner*, **37**, 259–262, 1958.
(3) Emery, A. H., *Chem. Eng. News*, 87, June 20, 1960.
(3a) Feinstein, P., *Special Libraries*, **53**, 26 (1962).
(4) Findlay, G. M., *Chem. and Ind.*, 819–21, (1949).
(5) Furman, M. S., et al., *Khim. Prom.*, **1960**, 265–72.
(6) Fussler, H. S., *The Library Quarterly*, **19**, 120, (1949); *American Institute of Physics Documentation Newsletter*, January 2, 1960.
(7) Keldysh, M. V., *Vesin. Akad. Nauk SSSR*, **31**, 14–39 (1961).
(7a) DeWitt, N., "Education and Professional Employment in the USSR," U. S. Government Printing Office, Washington, D. C., 1961, p. 341.
(8) Korshak, N. N., et al., *Vysokomolekul. Soedin.* **2**, 1246–8, (1960).
(9) For example, Moldavskiĭ, B. L., et al., *Zh. Obsch. Khim.*, **16**, 427–34, 1946; *Zh. Prikl. Kh.*, **32**, 2771–6, (1959); **33**, 417–20 (1960).
(10) National Science Foundation, Report on the National Register of Scientific and Technical Personnel, 1962.
(11) See, for instance, *New York Journal of Commerce*, September 26, 1960, pp. 2, 6; *Oil Daily*, September 26, 1960, p. 1; "U.S. Oil Men Take A Look at Russia," based on the observations of the first U.S. Petroleum Industry Exchange Delegation to Russia, August 2–31, 1960.
(12) Tolpin, J. G., *Chem. Eng. Prog.*, **56**, 6–10, September 1960.
(13) Tolpin, J. G., *Science*, **132**, 1679–80, (1960).
(14) See, for instance, Topchiev, A. V., *Vestn. Akad. Nauk SSSR*, **30**, 1–9 (1960).
(14a) Anonymous, *Ekonomicheskaya gazeta*, p. 1, July 31, 1960.
(15) Voigt, M. J., *Libri*, **9**, 177–93, (1959).
(16) Weiss, P., *Science*, **131**, 1716, 1960.

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A Simple Pressure Stopcock

Many devices have been developed for converting standard stopcocks into pressure stopcocks. Most of these are based on attaching a screw to the plug and pressing it into the shell by means of a spring and nut, such as the device described by Hamilton.[2] Since then many modifications and simplifications have appeared.

Further simplification was desired and a new attachment shown in the figure was developed. It consists of three simple parts: (1) a standard rubber O-ring, (2) a plastic nut with a counterbore, and (3) a plastic screw with under-cut and 4 longitudinal slits.

The rubber O-ring may be of standard composition and a Parker #2-111 is recommended for the 2-mm size stopcock. The plastic parts may be machined from high density polyethylene or preferably polypropylene. A $^1/_2$-20 thread is recommended for the 2-mm size stopcock. The 4 longitudinal slits in the undercut portion of the screw permit it to be snapped over the knob at the end of the plug. This allows the prongs of the screw to snap over the knob of the plug and fit into the groove. Also before assembly, the O-ring is placed over the end of the plug; the counterbore in the nut acts as a housing for the O-ring. The pressure on the plug is adjusted by carefully tightening the nut against the O-ring. This adjustment may be made easily to give a hold on the plug without unduly squeezing the lubricant from between the plug and shell.

Acknowledgement. Permission to publish this note by the Kontes Glass Company is gratefully acknowledged. The assistance of W. R. Linton, master machinist for the Kontes Glass Company, in helping to complete the design and prepare prototypes is also greatly appreciated.

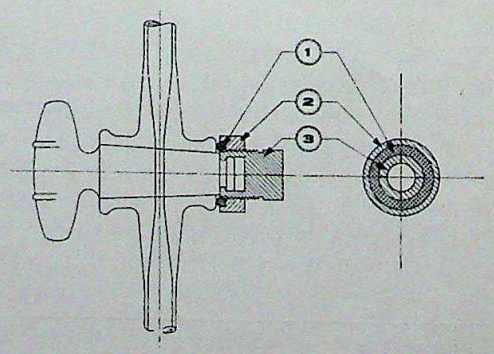

Figure 1

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[2] Hamilton, R. H., *Ind. Eng. Chem., Anal. Ed.*, **19**, 360 (1947); also U. S. patents 2,642,258 and 2,672,315.

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Proceeding of the
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The Lighter Lanthanides

A laboratory experiment in rare earth chemistry

Great advances are now being made in our knowledge of the chemistry of the rare earths, and compounds of these elements are no longer rare. These two essential facts have unfortunately not yet filtered down to many high school and undergraduate college chemistry instructors, the group primarily responsible for chemical education in this country. That an hiatus exists between the research frontier and the classroom is to be expected, but the unusual teaching value inherent in this largest natural group of metals, their relationship to the actinide series, and the student motivation derived from their "exotic" status, make it especially important that attempts be made to reduce this gap. Particularly needed are reproducible laboratory experiments specifically designed for undergraduate college or high school courses.

As an example we offer the present experiment, which is schematically summarized in Table 1. It stresses basic principles encountered in traditional courses as well as phenomena peculiar to the rare earths. Our approach is an heuristic one; although the experiment can be performed exactly as described, we hope that it will also serve to stimulate original thinking about rare earths and give those educators whose primary interest lie outside these elements an inkling of what can be done in a school laboratory with simple equipment and a few inexpensive raw materials.

In this experiment, important separation methods such as precipitation, crystallization, redox reactions, and complex formation, which have been largely overshadowed by ion exchange, are illustrated (ref. (*1*), pp. 65–86, ref. (*2*), pp. 40–48). Here many of the complex and tedious procedures characteristic of rare earth separations are simplified for student use although admittedly at sacrifice of purity and yield. Our primary purpose is to illustrate, with a reasonable expenditure of time, the separation and properties of rare earths. If pure products are desired, the more time-consuming procedures given in the original literature should be consulted.

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Table 1. Separation of Lindsay Code 330 Rare Earth Oxide into Ce, La, Pr, and Nd. For Details See "The Experiment."

Dissolve the sample in HNO_3 and heat. Save the solution containing Ce^{4+}, La^{3+}, Nd^{3+}, and Pr^{3+}. Add NH_4NO_3.

- *Precipitate:* Dissolve $(NH_4)_2Ce(NO_3)_6$ in water. Add H_2O_2 to reduce to Ce^{3+}. Dilute with H_2O, and heat to boiling. Add Na_2SO_4.
  - *Precipitate:* Add H_2O to $Ce_2(SO_4)_3 \cdot Na_2SO_4 \cdot 2H_2O$, and add NaOH pellets.
    - *Precipitate:* $Ce(OH)_3 \xrightarrow{KMnO_4} Ce(OH)_4, MnO_2$; $\downarrow O_2$; $Ce_2(OH)_2(OH)_3$; $\downarrow O_2$; $Ce(OH)_4$; $\xrightarrow{H_2O_2}$ $Ce(OH)_3$; $\downarrow HCl$; Ce^{3+}, Cl_2; $\downarrow H_2O_2$; $Ce(OH)_4$
    - *Solution:* Discard.
  - *Solution:* Discard.
- *Solution:* La^{3+}, Nd^{3+}, Pr^{3+}, Ce^{4+}, evaporate and add H_2O_2.
  - *Precipitate:* $La(NO_3)_3 \cdot 2NH_4NO_3 \cdot 4H_2O$, run tests for Ce^{3+}, Nd^{3+}, and Pr^{3+} —see section 3. Dissolve remaining precipitate in water, add $CaCO_3$ and $KBrO_3$, and evaporate. Dilute with water.
    - *Precipitate:* $Ce(OH)_x(NO_3)_{4-x}$, spot test — see section 4.
    - *Solution:* La^{3+}, add NH_4NO_3 and NH_3, and heat.
      - *Precipitate:* $Nd(OH)_3$, $Pr(OH)_3$. Either discard, or dissolve in HNO_3 and add to Nd-Pr filtrate.
      - *Solution:* La^{3+}, add $(CH_3)_2C_2O_4$. $La_2(C_2O_4)_3$ will precipitate. Ignite to form La_2O_3 — see section 6.
  - *Solution:* Nd^{3+}, Pr^{3+}, either separate by ion exchange or add $(NH_4)_3HY$—see section 7.

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Reference to primary sources is given in order to encourage students to consult the literature; major reference, however, is directed to the standard texts in this field (*1*, *2*) so that students in institutions with modest libraries will not be handicapped.

Electronic Configurations

The rare earths, which consist of the lanthanides, lanthanum (at. no. 57) through lutecium (at. no. 71), plus scandium (at. no. 21) and yttrium (at. no. 39) in periodic group III-B, are closely related, not only in the periodic table but also in nature. In considering the implications of the periodic table, long a familiar part of every high school or freshman chemistry course, the instructor cannot avoid referring to this family, if only to dismiss them uneasily with the statement that they do not readily "fit" into the table. In the light of modern orbital theory, however, their physical and chemical properties are seen as logical consequences of their electronic configurations.

The marked similarity in chemical properties among lanthanides is due to a close similarity in electronic structures, either $4f^n5d6s^2$ or $4f^{n+1}\ 6s^2$. Although chemists and physicists differ slightly in their choice of configurations, those of the tripositive ions are the same on either basis. The regular filling of the $4f$ orbitals with n electrons from La($4f^0$) through Lu($4f^{14}$) is reflected in a corresponding periodicity in physical and chemical properties.

A familiar example is the Main-Smith color sequence ((*3*), ref. (*1*), p. 42, ref. (*2*), p. 20), which is shown in Table 2 for the ions in this experiment. A trivalent lanthanide ion having n electrons more than La^{3+} has almost the same color as an ion with 14-n electrons more, since both possess the same number of unpaired electrons according to Hund's rule of maximum multiplicity.

Oxalic Acid, The Lanthanide "Group Reagent"

One property shared by all lanthanides is the insolubility of their oxalates in acid solution. Consequently, oxalate precipitation is often used for rapid separation of lanthanides from other elements. Oxalates are particularly attractive derivatives since on ignition they yield oxides, which can be dissolved in acids (sections 3 and 5):[2]

$$Ln_2(C_2O_4)_3 \rightarrow Ln_2O_3 + 3CO_2\uparrow + 3CO\uparrow$$

In section 5, La is precipitated by the long known but only recently exploited technique of homogeneous precipitation (*4*). Methyl oxalate, which hydrolyzes in boiling aqueous solution to generate oxalic acid *in situ*, produces a coarsely crystalline, easily filterable product (*5*, *6*). No oxalate of cerium(IV) is known, since oxalic acid reduces Ce^{4+} ion (section 3):

$$2Ce^{4+} + 4C_2O_4^{2-} \rightarrow Ce_2(C_2O_4)_3\downarrow + 2CO_2\uparrow$$

[2] Section numbers refer to the experimental procedure.

The Lanthanide Contraction

This term, coined by the geochemist V. M. Goldschmidt (*7*), refers to the diminution in atomic and ionic radii which begins with lanthanum (La^{3+}, 1.22Å) and continues regularly throughout the rare earth series through lutecium (Lu^{3+}, 0.99Å). Because it is a natural consequence of an increase in nuclear charge without a compensating increase in distance from the nucleus of the additional electrons, the contraction is not anomaly, and it should be considered in general chemistry courses along with other trends in atomic and ionic size. A student who has observed the decreasing basicity and increasing amphotericity in Group II-A from Ra^{2+} to be Be^{2+} should encounter no difficulty with the similar trend seen among the trivalent lanthanides.

The small but important differences in properties between trivalent lanthanides which form the basis for most separational procedures (ref. (*2*), p. 58) may be ascribed to these size differences. For example, the lanthanide contraction is exploited in the fractional precipitation of hydroxides, which affords the basis for a number of separations of La from the other, less basic lanthanides (*8*), ref. (*1*), pp. 102, 157). As ionic radii decrease (e.g., La^{3+}, 1.22Å; Pr^{3+}, 1.16Å; Nd^{3+}, 1.15Å), the basicities and solubilities of trivalent lanthanide hydroxides decrease as shown by K_{sp} values (La^{3+}, 1.0×10^{-19}; Pr^{3+}, 2.7×10^{-20}; Nd^{3+}, 1.9×10^{-21}) (*9*, *10*) and pH values for incipient precipitation (La^{3+}, 8.03; Pr^{3+}, 7.05; Nd^{3+} 7.02) (*11*, *12*). In section 5, the Trombe method (*13*, *14*) as modified by Vickery ((*15*), ref. (*1*), p. 105) is used to precipitate Pr^{3+} and Nd^{3+} as hydroxides, leaving most of the La^{3+} in solution. By bubbling air containing NH_3 through a boiling, buffered solution, this method not only avoids the dilution produced by aqueous NH_3 but also permits closer pH control and yields denser, more easily filterable precipitates.

The consequences of the lanthanide contraction are not, however, limited to the lanthanides, but have profound effects on atomic volumes, ionization potentials, densities, and other properties of elements in widely separated areas of the periodic table (*16*). Thus, the marked similarities in size and properties between corresponding pre-lanthanide and post-lanthanide elements such as Zr-Hf, Nb-Ta, and Mo-W are direct results of the lanthanide contraction (*17*).

Fractional Crystallization, Precipitation, and Complex Formation

Although most compounds vary regularly in solubility throughout the lanthanide series as a result of the lanthanide contraction, most of the fractional crystallizations and precipitations used for separation purposes involve double and complex salts rather than simple compounds. For example, in section 1, the

Table 2. Main-Smith Color Sequence

Ion	Color	Configuration	Unpaired electrons	Configuration	Color	Ion
La^{3+}	Colorless	$4f^0$	0	$4f^{14}$	Colorless	Lu^{3+}
Ce^{3+}	Colorless	$4f^1$	1	$4f^{13}$	Colorless	Yb^{3+}
Pr^{3+}	Yellow-green	$4f^2$	2	$4f^{12}$	Pale green	Tm^{3+}
Nd^{3+}	Red-violet	$4f^3$	3	$4f^{11}$	Rose	Er^{3+}

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complex lanthanide mixture is separated by fractional crystallization of the isomorphous double ammonium nitrates (ref. (*1*), pp. 70,115), the method used by Baron Auer von Welsbach (*18*) for his classic separation of didymium into praseodymium and neodymium. Three fractions are obtained in order of increasing solubility (numbers in parentheses give the relative solubilities of the double ammonium nitrates at 20°C): Ce^{4+} (<0.7); La^{3+} (1.0) and Ce^{3+} (1.5); and Pr^{3+} (1.7) and Nd^{3+} (2.2). After removal of fraction 1, the remaining Ce^{4+} is reduced to Ce^{3+}, which interpolates between La^{3+} and Pr^{3+} and thus increases the efficiency of separation between fractions 2 and 3. Ce^{3+} is employed as "l'élément séparateur"—an element, usually deliberately introduced which, by virtue of solubility or ionic radius, falls between two difficultly separable lanthanides (ref. (*1*), pp. 72, 115).

Fractional precipitation differs from fractional crystallization in that no diminution in volume or temperature change is involved. Double sodium sulfates (ref. (*1*), pp. 87, 236) are probably the most generally employed compounds for the fractional precipitation of lanthanides; Na_2SO_4 is used in section 2 to precipitate and concentrate cerium(III), whose redox chemistry is then examined in some detail.

Fractional separations need not involve a solid phase; in section 7, the presence of Pr in the pink filtrate from section 1 is detected by fractional complex formation with the ethylenediaminetetraacetate (Y^{4-}) ion (*19*). As expected from the lanthanide contraction, the smaller Nd^{3+} ion is more readily complexed than is the larger Pr^{3+} ion:

$$Ln^{3+}HY^{3-} \leftrightharpoons H^+ + [LnY]^- \qquad \log K_{293} = 16.75(Nd^{3+});\ 16.55(Pr^{3+})$$

This behavior has been used in a chromatographic ion exchange separation of Nd from Pr (*20, 21*).

Redox Reactions

Most separations of lanthanides in the trivalent oxidation state are only partially successful and often require several repetitions; however, if a lanthanide can be oxidized or reduced, its separation from trivalent lanthanides is often extremely simple and efficient. Many of the oxidation states other than 3^+, sometimes incorrectly termed "anomalous valences," can be attributed to the tendency for the trivalent ions to lose or gain electrons in attempts to attain one of three stable electronic configurations. Thus, Ce^{4+} has the inert gas (Xe) configuration ($4f^0$) of La^{3+}; Eu^{2+} and Tb^{4+}, the half-filled orbital configuration ($4f^7$) of Gd^{3+}; and Yb^{2+}, the filled orbital configuration ($4f^{14}$) of Lu^{3+}.

Cerium, the commonest of the rare earths, and the only lanthanide that forms a tetravalent ion has long been separated and purified by oxidation. Ce^{4+} ion is weakly basic and readily hydrolyzes at a precipitation incidence of *p*H 2. In section 4, residual cerium is removed from La^{3+}, Nd^{3+}, and Pr^{3+} by oxidation with potassium bromate:

$$10Ce^{3+} + 2BrO_3^- + 12H^+ \rightarrow 10Ce^{4+} + Br_2\uparrow + 6H_2O$$

followed by dilution, which causes precipitation of a basic nitrate (ref. (*1*), p. 125):

$$Ce^{4+} + xH_2O + (4-x)NO_3^- \leftrightharpoons Ce(OH)_x(NO_3)_{4-x}\downarrow + xH^+$$

Marble chips are added to neutralize the liberated acid and allow the reaction to proceed to completion.

In this experiment, Ce^{4+} is reduced to Ce^{3+} not only by $C_2O_4^{2-}$ as mentioned above, but also by hydrogen peroxide in *acid* solution (section 1). In section 2, the Ce^{3+} is converted to the hydroxide, which can be preserved only if dried and stored in the absence of air. According to Barbieri (*22*), the view that Ce(IV) compounds are unstable with respect to Ce(III) compounds is incorrect (ref. (*1*), p. 215). Actually it is the Ce^{4+} *ion* that is readily reduced to the Ce^{3+} *ion*. In a basic medium in which Ce^{4+} ions cannot exist because of the insolubility of $Ce(OH)_4$, Ce(IV) compounds are stable while cerium(III) compounds act as reducing agents. In an acid medium, on the other hand, cerium(IV) compounds are strong oxidizing agents as shown by the evolution of chlorine when $Ce(OH)_4$ is dissolved in hot hydrochloric acid (ref. (*1*), p. 215). However, in an acid solution in which conditions are such as to reduce the concentration of Ce^{4+} ions, e.g., in HNO_3 where $Ce(NO_3)_6^{2-}$ complexes are formed (ref. (*1*), p. 231, ref. (*2*), p. 61), cerium(IV) is stable, and the oxidation of Ce^{3+} can be effected by HNO_3 alone as in section 1. In accordance with the above, H_2O_2 acts as a reducing agent toward Ce(IV) in acid solution:

$$2Ce^{4+}\text{(red-orange)} + H_2O_2 \rightarrow 2Ce^{3+}\text{(colorless)} + 2H^+ + O_2\uparrow$$

and as an oxidizing agent toward Ce(III) in basic solution:

$$2Ce(OH)_3\text{ (white)} + H_2O_2 \rightarrow 2Ce(OH)_4\text{ (yellow)}$$

Because of the high oxidation potential of the Ce(III)–Ce(IV) couple, Ce(IV) salts are widely used as stable titrimetric oxidizing agents in analytical chemistry (*23, 24*).

The Experiment

The material used in this experiment, Lindsay Code 330 rare earth oxide, is obtained by chemical extraction of monazite sand, the principal rare earth ore. Hence the composition of the mixture is very similar to that of the ore itself, a typical percentage analysis being: CeO_2, 45.6; La_2O_3, 22.8; Nd_2O_3, 16.2; Pr_6O_{11}, 4.7; Gd_2O_3, 1.9; Y_2O_3, 0.2; other rare earth oxides, 0.8. Most large scale applications of rare earths are based on this type of material, which is produced in tonnage quantities. Among the most inexpensive of rare earth raw materials, it admirably supports our contention that rare earths are no longer rare. At current market prices, the cost of the 10 g of rare earth oxide used in this experiment is about six cents.

Section 1: Fractional Crystallization of Double Ammonium Nitrates

Ten grams of Lindsay Code 330 rare earth oxide (*ca.* 0.05 mole of rare earths) is heated with 70 ml of 1:1 HNO_3 (*hood*) until most of the solid has dissolved and the volume has been reduced to 40 ml. Any black residue (of undecomposed zircon, ilmenite, etc.) is removed by filtration through a sintered glass funnel, and 7 g of NH_4NO_3 is added *slowly with stirring*

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to the hot red-orange filtrate. Evaporation to a volume of 30 ml, followed by *slow* cooling to room temperature produces an orange, crystalline precipitate, which is collected by suction filtration. Excess NH_4NO_3 may result in a pasty precipitate. The volume is critical; greater than 30 ml may result in two crops of $(NH_4)_2Ce(NO_3)_6$, while less than 30 ml may lead to premature crystallization of $La(NO_3)_3 \cdot 2NH_4NO_3 \cdot 4H_2O$.

The light yellow filtrate is evaporated to a volume of 10 ml, and 10 drops of 30% H_2O_2 is added to the hot syrup (*effervescence*) in order to reduce Ce^{4+} to Ce^{3+}. On slow cooling to room temperature, finely divided, very pale violet crystals of $La(NO_3)_3 \cdot 2NH_4NO_3 \cdot 4H_2O$ are obtained. The material is transferred to a sintered glass funnel and pressed down with a cork or rubber stopper while the adhering Nd^{3+}–Pr^{3+} mother liquor is drained by suction. The double ammonium nitrate of La^{3+} (16 g) is contaminated with those of Ce^{3+}, Nd^{3+}, and Pr^{3+}. On dilution, the turbid Nd^{3+}–Pr^{3+} filtrate becomes clear and exhibits the pink color of Nd^{3+}.

Section 2: Metathetical and Redox Reactions of Ce

The orange $(NH_4)_2Ce(NO_3)_6$ (9 g) is dissolved in a minimum amount of water (12 ml), and the Ce^{4+} is reduced to Ce^{3+} by adding sufficient 30% H_2O_2 (1 ml) to almost decolorize the solution (*effervescence*). The light violet solution thus obtained is diluted to 0.5% $(NH_4)_2Ce(NO_3)_6$ concentration (180 ml), heated to boiling, and treated with a slight excess (8 g) of anhydrous Na_2SO_4. The white, crystalline precipitate of $Ce_2(SO_4)_3 \cdot Na_2SO_4 \cdot 2H_2O$ is collected by suction filtration, washed with two 10-ml portions of water, and stirred into 20 ml of water. NaOH pellets (2 g) are added to the slurry, and the mixture is warmed until the pellets have dissolved. The off-white *granular* precipitate of $Ce(OH)_3$ is *immediately* collected on a Büchner (*not sintered glass*) funnel, washed with 10 ml of water, and air-dried by suction. For comparison purposes, cerium(III) hydroxide can be precipitated in *gelatinous*, hydrated form by adding excess aqueous NH_3 to a cerium(III) salt solution (ref. (*2*), p. 60).

The powerful reducing action of $Ce(OH)_3$, a characteristic shared with all Ce^{3+} salts which distinguishes such salts from all other trivalent lanthanides, is also shown by the almost instant decolorization of dilute $KMnO_4$ solution (ref. (*1*), p. 214).

As air is sucked through the *granular* $Ce(OH)_3$, a series of color changes occurs (violet → dark purple → tan → green-yellow). The stepwise oxidation eventually terminates in stable, yellow $Ce(OH)_4$ (*25*). A similar complicated reaction, the basis for a Ce^{3+} spot test (*cf.* section 4) occurs *immediately* on addition of 30% H_2O_2, but intermediate steps are not visible (*26*).

Section 3: Presence of Ce, Pr, and Nd in the La Fraction

The following reactions show the presence of Ce in the La fraction and also illustrate further the redox behavior of Ce: A 1-g portion of lanthanum ammonium nitrate is dissolved in 20 ml of water. One drop of 0.1 *M* $AgNO_3$, 0.5 ml of H_2SO_4, and 0.2 g of potassium peroxydisulfate ("persulfate") are added. On boiling, the yellow color of Ce(IV) appears. If a concentrated oxalic acid solution is added to this Ce^{4+}–La^{3+} solution, the yellow color disappears and a white precipitate of $Ce_2(C_2O_4)_3$ and $La_2(C_2O_4)_3$ forms. That Pr and Nd are still present can be shown by collecting the oxalate precipitate by suction filtration, washing it with water, and igniting it at 1000°C. The residue obtained is brown rather than white, and on treatment with water it does not evolve heat or give a basic slurry as does pure La_2O_3.

Section 4: Removal of Ce from the La Fraction (27)

The remainder of the lanthanum ammonium nitrate (*ca.* 15 g) is dissolved in 50 ml of water in a 250-ml evaporating dish. Several marble chips are added to the strongly acidic, pink solution (*effervescence*), and the mixture heated with stirring and addition of water to replace that lost by evaporation. When the *p*H has risen to 5 (Hydrion paper), 0.3 g of potassium bromate is added and the mixture evaporated to a viscous paste (*constant stirring*). *Powdered* $CaCO_3$ should be added during evaporation if Br_2 fumes are noticeable. The mixture is diluted to 50 ml whereupon Ce(IV) is precipitated as a cream-colored, insoluble basic nitrate. The evaporation (oxidation) and dilution (hydrolysis) steps are repeated (4 times) until the following spot test (sensitive to 1 part in 10,000) shows the absence of Ce (ref. (*1*), pp. 216, 266). Over a bottle of aqueous NH_3 is held a piece of filter paper on which a drop of supernatant liquid and a drop of 30% H_2O_2 have been placed. A yellow spot of $Ce(OH)_4$ indicates the presence of Ce. After the diluted mixture has cooled, it is filtered, and the Ce-containing residue discarded.

Section 5: Removal of Pr and Nd from the La Fraction

After being diluted to a volume of 75 ml, the pink, Ce-free La solution (section 4), which still contains Nd and Pr, is placed in the round-bottom flask shown in Figure 1, 25 g of NH_4NO_3 is added, and the solution is heated and kept at the boiling point. Air is sucked through the apparatus (aspirator) at such a rate that the bubbles in the filter flask containing 1:1 NH_3 form just too rapidly to be counted. After 5 min, turbidity and foaming indicate incipient precipitation of hydroxides (mainly $Nd(OH)_3$ and $Pr(OH)_3$). After an additional 15 min, the light violet precipitate is removed by filtration. The filtrate is returned to the

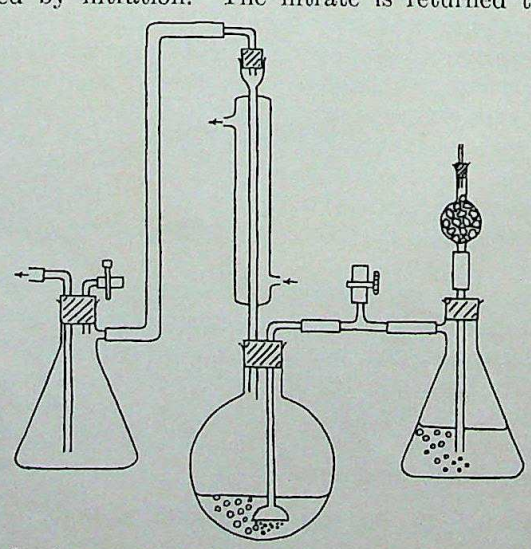

Figure 1. Apparatus for the Trombe-Vickery air-borne purification of lanthanum. All rubber tubing is pressure tubing except the two pieces controlled by clamps.

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flask, reheated, and the entire process repeated using a new filter paper. After two precipitations, the filtrate is generally colorless, but the presence of Pr-and Nd-can be shown by treating a small portion of filtrate with $H_2C_2O_4$ solution, collecting and igniting the precipitated oxalate, and observing the brown color of the resulting oxide (section 3). Fractional precipitation is continued until the oxide so obtained is pure white (5 precipitations). The hydroxides obtained from the first two precipitations may be dissolved in minimum 1:1 HNO_3 and added to the Nd^{3+} – Pr^{3+} filtrate obtained in section 1.

The La is precipitated from the Nd and Pr free filtrate by adding 15 ml of $(CH_3)_2C_2O_4$ solution, boiling vigorously, and cooling in an ice bath for $^1/_2$ hr, or preferably overnight since oxalate precipitation is often slow. The methyl oxalate solution (0.266 g $C_2O_4^{2-}$/ml) is prepared by dissolving 20 g of anhydrous $H_2C_2O_4$ (prepared by heating the dihydrate at 100°C for 4 hr with occasional powdering of the glassy crust) in 50 ml of absolute methanol and allowing the solution to stand for 3 days (*28*). The reduction by oxalate of the excess bromate added in section 4 may produce Br_2 (orange color) on boiling. The superiority of homogeneous over heterogeneous precipitation can be shown by comparison of the precipitate obtained with that resulting from direct addition of $H_2C_2O_4$. The $La_2(C_2O_4)_3$ is collected by suction filtration, washed, air-dried, and ignited at 1000°C for at least 2 hr, and the white La_2O_3 cooled in a desiccator.

Section 6: Properties of La

Purity of the La_2O_3 obtained can be determined by calculating the average atomic weight, a useful method long used in following the progress of lanthanide separations. A weighed sample of oxide is dissolved in excess standard acid, the lanthanides are precipitated with excess $K_2C_2O_4$ solution, and the excess acid determined by titration with standard base using bromcresol purple indicator.

As was predicted in our previous discussion of the influence of the lanthanide contraction, La_2O_3 is the most basic of lanthanide oxides, and its similarity to lime (CaO) can be shown by the following tests. When heated in a Meker burner flame, La_2O_3 produces a white glow, which may be compared with that produced by CaO or ThO_2. The evolution of heat and formation of a strongly basic hydroxide can be shown by adding a little water, stirring with a thermometer, and testing the slurry with Hydrion paper. When exposed to air for several hours, La_2O_3 absorbs CO_2, as treatment of the product with HCl shows (*effervescence*). The characteristic lanthanum blue reaction can be demonstrated by converting La_2O_3 to a colloidal suspension of basic lanthanum acetate which, like starch, produces a blue color with I_2 (*29–31*). A student in qualitative analysis may be given a La_2O_3 sample as an "unknown" and asked to determine the position in the "qual" scheme of La and of rare earths in general.

Section 7: The Nd-Pr Fraction

One gram of disodium dihydrogen ethylenediaminetetraacetate 2-hydrate ($Na_2H_2Y \cdot 2H_2O$) is dissolved by stirring into 10 ml of water containing 0.5 ml of concentrated aqueous NH_3. If 4 ml of this solution is added to 2 ml of a solution prepared by diluting the Nd-Pr filtrate 1:1 with water, the Nd^{3+} is complexed, allowing the previously obscured green color of the Pr^{3+} ion to show. If the *p*H is raised by adding 4 ml of NH_3, the Pr^{3+} is also complexed, resulting in a color shift to violet-gray. Fractional complex formation with EDTA can be used to separate Nd from Pr according to the chromatographic method of Kauffman and Blank (*21*). To improve visual observation of the separation, the original Nd-Pr filtrate should be enriched with additional Pr.

Acknowledgment

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Literature Cited

(1) Vickery, R. C., "Chemistry of the Lanthanons," Academic Press, Inc., New York, 1953.
(2) Yost, D. M., Russell, H., and Garner, C. S., "The Rare-Earth Elements and Their Compounds," John Wiley and Sons, Inc., New York, 1947.
(3) Main-Smith, J. D., *Nature*, **120**, 583 (1927).
(4) Gordon, L., Salutsky, M. L., and Willard, H. H., "Precipitation from Homogeneous Solution," John Wiley and Sons, Inc., New York, 1959.
(5) Willard, H. H., and Gordon, L., *Anal. Chem.*, **20**, 165 (1948).
(6) Gordon, L., and Caley, E. R., *Anal. Chem.*, **20**, 560 (1948).
(7) Goldschmidt, V. M., *Z. Elektrochem.*, **34**, 453 (1928); *Trans. Faraday Soc.*, **25**, 253 (1929).
(8) Fogg, H. C., and Hess, L., *J. Am. Chem. Soc.*, **58**, 1751 (1936).
(9) Moeller, T., and Kremers, H. E., *J. Phys. Chem.*, **48**, 395 (1944).
(10) Endres, G., *Z. anorg. Chem.*, **205**, 321 (1932).
(11) Bowles, J. A. C., and Partridge, H. M., *Ind. Eng. Chem., Anal. Ed.*, **9**, 124 (1937).
(12) Britton, H. T. S., *J. Chem. Soc.*, **127**, 2142 (1925).
(13) Trombe, F., *Compt. rend.*, **215**, 539 (1942).
(14) Trombe, F., Gaume-Mahn, F., and Carminati-Delauney, Mme., *J. recherches centre natl. recherche sci., Labs. Bellevue*, **35**, 113 (1956).
(15) Vickery, R. C., *J. Chem. Soc.*, **1949**, 2506.
(16) Keller, R. N., this Journal, **28**, 312 (1951).
(17) Moeller, T., "Inorganic Chemistry," John Wiley and Sons, Inc., New York, 1952, pp. 146–51.
(18) von Welsbach, A. C., *Ber.*, **18**, 605 (1885); *Monatsh. Chem.*, **6**, 477 (1885).
(19) Powell, J. E., Spedding, F. H., and James, D. B., this Journal, **37**, 629 (1960).
(20) Spedding, F. H., Powell, J. E., and Wheelwright, E. J., *J. Am. Chem. Soc.*, **76**, 2557 (1954).
(21) Kauffman, G. B., and Blank, J. S., this Journal, **37**, 156 (1960).
(22) Barbieri, G. A., *Atti. accad. Lincei*, **16**, 395 (1907).
(23) Willard, H. H., and Young, P., *J. Am. Chem. Soc.*, **50**, 1322 (1928); Furman, N. H., *J. Am. Chem. Soc.*, **50**, 755 (1928).
(24) Smith, G. F., "Cerate Oxidimetry," G. Frederick Smith Chemical Co., Columbus, Ohio, 1942.
(25) Wyrouboff, G. N., and Verneuil, A., *Ann. chim. phys.*, **9**, 289 (1906).
(26) Lawson, A., and Balson, E. W., *J. Chem. Soc.*, **1935**, 362.
(27) Pearce, D. W., and Butler, J. C., *Inorganic Syntheses*, **2**, 48 (1946).
(28) Carron, M. K., Skinner, D. L., and Stevens, R. E., *Anal. Chem.*, **27**, 1058 (1955).
(29) Krüger, D., and Tschirch, E., *Ber.*, **63b**, 2776 (1929); **62b**, 826 (1930); Kutzelnigg, A., and Wagner, W., *Z. anorg. Chem.*, **234**, 150 (1937); Kimura, K., and Ikeda, N., *Bull. Chem. Soc. Japan*, **21**, 19 (1948).
(30) Biltz, H., Biltz, W., Hall, W. T., and Blanchard, A. A., "Laboratory Methods of Inorganic Chemistry," John Wiley and Sons, Inc., New York, 1928, p. 45.
(31) King, A., "Inorganic Preparations," George Allen and Unwin Ltd., London, 1950, p. 123.

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Stereochemistry in the Terminal Course

If chemistry is to be the vehicle of elementary instruction in science, we should begin with stereoisomers and proceed (if we have time) to the simple compounds of oxygen, hydrogen, and nitrogen." This statement appeared in 1920 in a book by Norman Robert Campbell, a physicist.[1] There are obvious objections to it, probably not even Campbell expected it to be taken at face value, and certainly no one would do so nowadays. Nevertheless, the statement was made with a serious purpose which merits consideration.

It should be explained that the phrase "terminal course," as used in the present article, will refer not so much to a course taken by future biologists and engineers, who may make professional use of chemistry without specializing in it, as to a course taken by students majoring in history, foreign language, philosophy, and so on, who have a science requirement to meet. These students will make no professional use of chemistry; they are commonly required to take a course in science in the hope that they will benefit, as educated individuals and citizens, from some acquaintance with scientific thought.

The instructor in a chemistry course intended for such students has both a unique opportunity and a unique responsibility. Since he is not required to prepare his students for further work in the subject or to correlate his course with other science courses, he has the opportunity to select with an absolutely free hand the topics which his course shall cover. At the same time, he has a counterbalancing responsibility: he must take care to select those topics which will be of genuine value to the particular group of students with whom he is dealing; he is not justified in including a topic simply because every practicing chemist must be familiar with it. It is fair to say that both this opportunity and this responsibility have received less attention than they should have.

In making his free selection of course material, the instructor must accordingly have a clear conception of purpose. It is here contended that the primary purpose of a terminal course is—or should be—neither to impart a collection of chemical facts nor to present the current state of chemical theory; it is rather to show, by means of chemical examples, how science operates. The important thing is not what chemists believe, but the processes by which they arrive at their beliefs—the search for objective fact, the creation of theory, the interplay of fact and theory, and the perpetual modification and correction and growth which are so characteristic of science. In other words, the first aim of a terminal college course in chemistry, or in any other science, is to teach science as an intellectual activity, and thus *as one of the liberal arts.* Such a course will include plenty of important facts and theories, but they will not be an end in themselves; they will be a means to the comprehension of chemical thought. This is the kind of teaching which will help to ensure that the average citizen of tomorrow shall have a better understanding of science than the average citizen of today.

Campbell's argument, in the context of the sentence quoted above, is similar: namely, that the *ideas* of a science, which originate in the minds of men, are more significant in conveying an appreciation of the subject to the uninitiated than are the impersonal *facts* of the physical world, however fascinating the facts may appear to persons already scientifically inclined.

If all this be granted, it is clearly appropriate in a terminal course to devote much time to the origin and development of a few important chemical concepts; there is no better way to impart insight into scientific patterns of thought. Among these concepts, that of the molecule occupies a conspicuous place; not only is it absolutely indispensable for any introductory study of chemistry, but also it has evolved through a highly instructive sequence of stages.

The original concept of the molecule—the first of these stages of development—viewed it simply as the unit particle of a substance, consisting occasionally of a single atom but usually of several atoms clustered together; this concept dates back to Lomonosov, Higgins, and Dalton. Many years later, a second stage of development was brought about in the structural theory

[1] Campbell, N. R., "Physics: the Elements," Cambridge University Press, London, 1920, Chap. 8; reprinted in *Science*, 125, 803 (1957).

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of Kekulé, Couper, and Butlerov, which introduced the idea of discrete bonds between the atoms within a molecule. The third stage was reached when van't Hoff and Le Bel proposed the tetrahedral carbon atom and thereby—in mathematical terminology—replaced a topological concept of molecular structure by a geometrical one. The introduction of electronic theories of the chemical bond constituted the fourth stage.

Now, of these four stages, it is unquestionably the third which has received the least attention in terminal courses in chemistry. It is the purpose of the present article to suggest that this omission should be reconsidered. One can hardly maintain today that the study of chemistry should *start* with stereochemistry: when Campbell took this position in 1920, stereoisomerism represented the highest development of the most characteristically chemical concept, while the theory of the structures of simple molecules was in a much less satisfactory state; but this, of course, is no longer true. There remain, however, other reasons why the inclusion of stereochemistry is appropriate at a later point in the terminal course. Five of these may be mentioned here.

One noteworthy aspect of the topic is the small amount of scientific background knowledge required for its study; aside from the concepts of atoms and bonds, it is entirely geometrical and is open to direct demonstration. Moreover, the simple principles of stereochemistry lead to a great variety of individual situations; an instructor thus has abundant material from which to select illustrations and problems, and may develop the subject in greater or lesser depth as circumstances require. Third, stereochemistry is still an active field of research, and therefore provides one of the few possibilities for bringing students, even in a terminal course, clear up to the "growing edge" of chemistry through study of topics of current interest to chemists. Fourth, the introduction of models and mirrors lends welcome variety to the course by providing a visual as well as a verbal basis for discussion. And finally, by breaking away from a paper surface into three-dimensional space, stereochemistry combats the tendency of many students to approach chemistry as a study of words rather than things.

With these points in mind, the author some years ago included a certain amount of stereochemistry in the terminal course at Tufts University. The outcome of this innovation may be of interest to the readers of THIS JOURNAL.

For the reasons already described, the major topics in the Tufts terminal course are introduced in the historical—that is to say, the scientific—order: the observed facts first, and then the theories devised to account for them. The topic of stereochemistry, consequently, begins with the discovery of polarized light and of optical rotation, continues with Pasteur's work on the tartrates, and proceeds to the theoretical proposals of van't Hoff and Le Bel. Since experience has shown that most students are not clearly aware of the relationship between an object and its mirror image, the concept of dissymmetry is explained in detail. Planes of symmetry are introduced as an easy way of testing a given structure for the ability to exist in right- and left-handed forms, care being taken to point out that the presence of a plane of symmetry guarantees the symmetry of a structure, but that the absence of such a plane does not necessarily imply dissymmetry.

Geometrical isomerism is also dealt with historically, as a theoretical prediction which was successfully applied to the puzzling case of maleic and fumaric acids and was later verified in innumerable other cases. Finally, emphasis is placed on the visualization of three-dimensional structures from ordinary structural formulas, the point being made that these formulas do not *denote* the geometry but *imply* it.

This experiment cannot claim to be an unqualified success, but the results have been reasonably encouraging. Most conspicuous is the student interest aroused. On the one hand, facts of everyday experience are used directly to elucidate chemical concepts, while on the other hand the class discussion throws new light on familiar objects; this interplay has proved to be highly stimulating. Even those students who have had constant difficulty with concepts and have resigned themselves to trying to get through by memory alone seem to make a fresh effort at comprehension. Moreover, a student who has difficulty in visualizing geometrical relationships is clearly aware of the nature of his difficulty and is willing to struggle with it, whereas in other matters it is not uncommon for him to think that he understands what in fact he does not.

Despite the best efforts of both students and instructor, however, less than half of each class achieves a sufficient grasp of the essentials of stereochemistry to be able to give clear and correct answers to such modest problems as locating the planes of symmetry in methylene chloride (CH_2Cl_2), or describing the positions of the hydrogen atoms in cyclopentane (assuming the carbon ring to be planar). It is hardly remarkable that very few succeed in predicting the isomerism of substituted allenes—a problem assigned annually as homework since few students can be expected to be as clever as van't Hoff; but the failure to cope with simpler cases seems to leave no alternative to the conclusion that many students are simply incapable of the necessary three-dimensional visualizations. As a result, the two or three weeks spent on stereochemistry become to some extent a time of regrettable frustration.

A surprising feature of student response has been the lack of interest in handling models. It had been anticipated that nearly everyone would enjoy this aspect of the subject, but such has not been the case; despite urging, only a few of the better students will voluntarily try to assemble model structures. Poorer students, indeed, derive little benefit from models even if the latter are forced on them; this again points to inadequate three-dimensional visualization as the chief source of difficulty.

It has become abundantly clear that, if stereochemistry is to be taught at all in the terminal course, ample time must be allowed, and the various topics must receive a systematic and detailed presentation. Even such simple concepts as that of a plane cannot be taken for granted, and the geometrical features of a regular tetrahedron, for example, must be pointed out with great care.

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To sum up, it is possible to introduce stereochemistry into the terminal course; the topic arouses student interest and enlivens the class, in addition to possessing sound pedagogical value. At the same time, a considerable number of students fail to acquire any skill in solving stereochemical problems, apparently because they cannot visualize spatial relationships. Each instructor must decide for himself whether to accept the students' incapacity as a barrier and omit the topic, or to take it as a challenge and include it.

One final remark may be added. If stereochemistry is to be included in the terminal course, one is tempted to contemplate carrying it to the point of introducing conformational analysis, in order to impress students with the subtle details of molecular makeup to which our knowledge now extends. The experience of the Tufts course, however, indicates that the geometry involved would be too much for most terminal students. Furthermore, a considerable scientific background is needed for an appreciation of the evidence concerning this subject, and in a terminal course it is especially important not to present conclusions without evidence. Conformational analysis, accordingly, must be omitted.

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LETTERS

To the Editor:

I called attention (J. Chem. Educ., **37**, 161 (1960)) to the conflicting opinions concerning the use of dichromate cleaning solution. Quantitative results (on silica) have been reported recently by H. P. Dibbs (*Can. J. Chem.*, **40**, 565 (1962)) to the effect that "about 0.2 μg of chromium per apparent square centimeter of area remained after washing." Dibbs states that HF or HNO_3/H_2SO_4 mixtures remove some chromium, but leave significant amounts. Lewis and Boozer (*J. Am. Chem. Soc.*, **74**, 308 (1952)) suggest that an ammonia rinse followed by a second water rinse before drying is effective as judged by the effect on kinetic order; whether this is universally applicable is unknown.

I should like to offer still another pair of contrasting opinions about hazards associated with the use of another cleaning solution. J. R. Partington ("Textbook of Inorganic Chemistry," 6th ed., Macmillan and Co., London, **1950**, p. 908) wrote:

> When powdered $KMnO_4$ is added in small quantities at a time to cooled concentrated H_2SO_4, a dark green solution is formed which is liable to explode violently in contact with traces of organic matter, or even spontaneously.

On the other hand, G. A. Dean (*Can J. Chem.*, **40**, 550 (1962)) wrote:

> . . . powdered potassium permanganate (is added) to concentrated sulphuric acid with stirring, until the solution is deep green in color; the preparation and use of this solution is without hazard.

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BOOK REVIEWS

Elements of General and Biological Chemistry: An Introduction to the Molecular Basis of Life

John R. Holum, Augsburg College, Minneapolis, Minnesota. John Wiley and Sons, Inc., New York, 1962. ix + 470 pp. Figs. and tables. 15.5 × 23.5 cm. $5.95.

Experiments in General, Organic, and Biological Chemistry: A Laboratory Manual

John R. Holum. John Wiley and Sons, Inc., New York, 1963. viii + 119 pp. Figures. 22 × 28 cm. Paperbound. $2.95.

This book is presented for use in a one-semester or two-quarter course, with students who may have received no previous chemical training. The subject material in general chemistry is restricted to the absolute minimum the author considers necessary to gain an understanding of complex organic chemical structures and the sophisticated terminology of biochemical processes, which must be mastered before the theme of the book, the chemistry of the life processes at the molecular level, can be followed intelligently. General inorganic and physical chemistry is ruthlessly pruned to the first seven short chapters; the following six chapters deal with the organic chemistry of simple molecules. The subjects discussed, and the examples presented, are all designed to stress those aspects of chemistry which are involved in the life process in general, with particular emphasis on human metabolism. The remaining eleven chapters, almost half of the book, are devoted to the molecular basis of life. Chapters on the structure of proteins, carbohydrates, and lipids are followed by discussions of their metabolism, with interrelations at the detailed molecular level through the major metabolic cycles. Other chapters deal with enzyme action, the chemistry of heredity, physiological fluid balance, and aspects of radiation and radioactivity related to human physiology. The book is addressed to a wide audience, but it is clear that the subject material is presented with the specialist requirements of the future nurse as a principal objective, with detailed consideration of, for example, determination of D-glucose and acetone in pathological urine, and malfunctions in heme metabolism in relation to jaundice. Several of the experiments in the accompanying laboratory manual are relevan to the needs of the future nurse.

Modern biochemical concepts are stressed, with consideration of the mechanism of enzyme action, enzyme inhibition, and chemotherapy. Food metabolism is discussed in detail, and the interrelationships of the intermediates in the glycolytic, lipigenetic, fatty acid, citric acid, and other metabolic cycles are well presented so as to emphasize the unified nature of the metabolic processes at the molecular level. The chemistry of heredity is discussed on the basis of the Watson-Crick structure for DNA, with its implications on the structure of RNA and on protein synthesis.

Rather frequent errors and ambiguities, particularly in the general chemistry section, detract from the value of the book. On p. 110 it is implied that one of the bonds in the hydronium ion differs from the other two; the difference between a strong acid (sulfuric acid) and a weak one (boric acid) is illustrated by the fact that the former is corrosive while the latter can be used in eye-wash preparations. On p. 198 it is stated that $Cu(OH)_2$ is a mild reducing agent, and on page 199 hemiacetals are said to be rather exotic and obscure functional groups. The formulas used for sugar molecules on pages 252, 253, and elsewhere are not definitive for the structures described, and on page 260 hydrogen bonds are depicted between pairs of oxygen atoms, and between pairs of hydrogen atoms. The physico-chemical relationship between molecular weight of a solute and the osmotic pressure of a solution is not explained.

The non-technical reader, to whom the language of biological chemistry presents a formidable barrier, will find this book an excellent stepping stone to an understanding of modern developments. To provide a biochemical orientation for a general elementary course, the book could advantageously be used after a more detailed course in fundamentals. The book itself provides for the requirements of a brief course for nurses.

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Reviewed in this Issue

John R. Holum, Elements of General and Biological Chemistry:
George E. Ryschkewitsch, Chemical Bonding and the Geometry of Molecules
J. D. Fast, Entropy: The Significance of the Concept of Entropy and Its Applications in Science and Technology
Richard B. Hahn and *Frank J. Welcher*, Inorganic Qualitative Analysis:
S. Walker and *H. Straw*, Spectroscopy. Vol. 1, Atomic, Microwave, and Radio-Frequency. Vol. 2, Ultra-Violet, Visible, Infra-Red, and Raman
Virgil Boekelheide, editor-in-chief, Organic Syntheses. Volume 42
Grafton D. Chase and *J. L. Rabinowitz*, Principles of Radioisotope Methodology
L. M. Michejeva and *N. B. Michejev*, Radioaktive Isotope in der Analytischen Chemie
E. H. Rodd, editor, Chemistry of Carbon Compounds. Volume 5
R. A. Raphael, *E. C. Taylor*, and *H. Wynberg*, editors, Advances in Organic Chemistry: Volume 3
Klaus Biemann, Mass Spectrometry: Organic Chemical Applications
Kaj Linderstrøm-Lang, Selected Papers
M. Françon, Progress in Microscopy. Volume 9
Melville L. Wolfrom and *R. Stuart Tipson*, editors, Advances in Carbohydrate Chemistry. Volume 17
M. Stacey, *J. C. Tatlow*, and *A. G. Sharpe*, editors, Advances in Fluorine Chemistry. Volume 3
C. B. Anfinsen, Jr., editor, Advances in Protein Chemistry. Volume 17
The Harvey Lectures. Series 57
Klaus H. Behrndt, editor, Vacuum Microbalance Techniques. Volume 3
G. H. Bourne and *J. F. Danielli*, editors, International Review of Cytology. Volume 14
Harris Busch, editor, Biochemical Frontiers in Medicine.
Francis A. Gunther, editor, Residue Reviews. Volume 2

Chemical Bonding and the Geometry of Molecules

George E. Ryschkewitsch, University of Florida, Gainesville. Reinhold Publishing Corp., New York, 1963. 116 pp. Figs. and tables. 12.5 × 18.5 cm. $1.75.

In the fourth volume in the paperback series, Selected Topics in Modern Chemistry, George E. Ryschkewitsch goes exploring in the world of atoms, molecules, ions, and crystals. Although chemistry must remain empirical if it is to remain a science, it is certainly true that it has moved steadily forward from crude empiricism toward the deductive character of a mature discipline. This has happened because of the success which chemists have had in correlating the properties of substances with the structures of their constituent entities. As Sisler and VanderWerf say in their Series Editors' preface, this is "the heart of modern chemistry." A teacher and a productive experimental chemist, Ryschkewitsch has written a book which exposes the reader to the spirit of modern chemical research.

The inquisitive student cannot be required to wait until he has acquired mathematical sophistication before considering modern structural concepts. Thus, in a new and challenging sense, textbook authors nowadays are writing for the

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layman when they write for the beginning student. Ryschkewitsch's aim is to provide the student not only with information but with a measure of intellectual stimulation.

The evidence for the constitution of the atom provided by electrolysis, radioactive decay and the bombardment of metal foil with charged helium atoms is quickly surveyed in the first chapter, and the periodic arrangement of the elements by atomic numbers is presented.

The second chapter deals with the electronic structures of atoms. The first point developed is the difficulty in accounting for the fact that electrons are held to atoms by using simple electrostatic theory; next, the quantum nature of electromagnetic radiation; then, logically, to the conclusion that the energies of the atoms themselves have distinct values. This brings the reader up to 1913, one of the most important dates in the present century. Then come Heisenberg's Uncertainty Principle, de Broglie's matter waves, and the full application of the mathematical theory of waves to the description of electrons in atoms by Heisenberg and Schroedinger. The concept of the *orbital*, replacing the idea of a strictly defined orbit for an electron, is introduced next, along with the idea of four quantum numbers and Pauli's Exclusion Principle. A summary of the electron configurations of neutral isolated atoms is presented in the format of a periodic table.

Each chapter in this book is substantially longer than the one preceding it. The third chapter deals with ionic bonding and discusses such topics as ionization potential, electron affinity, dependence of crystal geometry on ion sizes and ion charges, and the Born-Haber cycle.

The fourth and last chapter devotes 47 pages to covalent bonding. The topics discussed in the first half of the chapter include orbital overlap, the octet rule and its limitations, electron pair donation, odd electron molecules, multiple bonding, formal charge, dipole moments, and electronegativity. These are discussed quite clearly and should be understandable to competent and interested first-year college students. The concluding 22 pages are devoted to molecular geometry. Bond lengths, bond angles and covalent radii are discussed, with meaningful examples; and it is shown how molecular geometries are accounted for from a consideration of electrostatic repulsions of electron pairs. The necessity for the concept of hybridization is explained and the sigma and pi bonding in ethylene are described. Resonance structures, electron delocalization, and the attendant increase in stability are the concluding topics.

Ryschkewitsch writes well and he includes useful diagrams and tables. A well-chosen list of selected readings is added as an appendix. In spite of its small size the book is carefully indexed. It is a valuable supplement for a student whose introductory text does not adequately or systematically discuss the correlation of structure with properties.

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Entropy: The Significance of the Concept of Entropy and Its Applications in Science and Technology

J. D. Fast, Technical University, Eindhoven, McGraw-Hill Book Co., Inc., New York, 1962. vii + 313 pp. Figs. and tables. 16 × 23.5 cm. $10.75.

This is a nice book. It is well written; the viewpoint is mature; it is rich in examples; and throughout, the pace and level of presentation are well suited to the author's purpose, which is "to reach all those students and researchers to whom thermodynamics and statistical mechanics seem a little frightening, although a certain knowledge of these subjects is indispensable to them."

Science students that possess an ordinary knowledge of calculus and a normal interest in their subject should find this an enjoyable book to study. Beyond that, students with a particular bent toward physical chemistry, or metallurgy, or the solid state, may find in it a deep source of understanding and, stemming from this, an inner satisfaction and inspiration to explore further in these areas the applications of thermodynamics and statistical mechanics. The book is an introduction to both disciplines and also to quantum mechanics.

The book is divided into six chapters of approximately equal length. It opens, after a brief general introduction, with a conventional, but readable discussion of classical, Clausius-Kelvin-type "black box" thermodynamics. Internal energy and entropy are introduced through a discussion of thermodynamic systems, states, and variables, exact and inexact differentials, reversible and irreversible changes, and Carnot's cycle.

The second chapter, The Statistical Significance of the Entropy Concept, nicely illustrates how to blend mathematical logic with apt examples to achieve a treatment that is both humane and robust. Dr. Fast treats large numbers and most probable states clearly and in some detail without getting bogged down in mathematical details. Included, also, is a discussion of Einstein's Solid (and the law of Dulong and Petit), the vibrational heat capacity of gases, and the Third Law.

The third chapter, Applications of the Concept of Entropy, may strike many teachers in this country—although not necessarily their students—as the least conventional chapter in the book. Not to be found is a discussion of Maxwell's relations, the Gibbs-Helmholtz equation, the Clausius-Clapeyron equation, colligative properties, the phase rule, or partial molal quantities. Instead, the examples chosen—the author says, "more or less at random," although there is to them a unity this statement does not reflect—include the following: the "free enthalpy" ($G=H-TS$), chemical equilibrium (illustrated chiefly by the reactions of oxygen with metals and carbon); paramagnetism and low temperatures (an unusually clear discussion of adiabatic demagnetization); interstitial atoms in body-centered cubic metals (probably the most authorative section of the book); substitutional alloys and ferromagnetism; vacancies and diffusion in solids; elasticity of rubber; solutions of polymers; black body radiation; and fuel cells and heat pumps.

The fourth chapter, Quantum Mechanics and Statistics, contains brief, but lucid, discussions of the uncertainty principle, the wave equation, and the statistics of Fermi-Dirac, Bose-Einstein, and Maxwell-Boltzmann. Appropriately, the particle in a box is treated in considerable detail. The chapter closes with nine pages on electrons in solids.

The last two chapters, The Entropy of Monatomic Gases and The Entropy of Diatomic Gases, contain more modern physical chemistry than one might suspect from their titles. Teachers and students alike should find these two chapters particularly useful for their well-worked out numerical examples.

Cover to cover, this carefully written book nicely illustrates the view that while a study of broad theories, such as statistical mechanics, which apply to many phenomena, is indeed often profitable, it is sometimes equally profitable and probably more in keeping with the general character of a growing science to focus attention at times upon a phenomenon, such as entropy, to which many theories apply.

"Entropy" could probably be used in some schools in a beginning physical chemistry course, if not as a text (it contains no problems), then as a reference or supplemental reading. Graduate students reviewing for examinations in physical chemistry should find it very useful; there is much in it they should know.

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Inorganic Qualitative Analysis: A Short Course for Introductory Chemistry

Richard B. Hahn, Wayne State University, Detroit, Michigan, and *Frank J. Welcher*, Indiana University, Bloomington. D. Van Nostrand Co., Inc., New York, 1963. ix + 304 pp. Figs. and tables. 14.5 × 21.5 cm. $4.95.

The authors state that this book was designed especially for courses in general chemistry which include qualitative analysis as the laboratory portion of the second semester. Their objectives are (1) to acquaint the student with the properties of common inorganic substances; (2) to apply this knowledge in the development of a system of inorganic qualitative analysis; (3) to study chemical equilibrium as it is applied to qualitative analysis; and (4) to teach useful laboratory techniques.

The book is divided into two parts: Theory and Laboratory. Part One consists of six chapters which cover the nature of qualitative analysis, solutions and colloids, and chemical equilibrium. Part Two presents some preliminary

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experiments, some discussions of the properties of the ions, and detailed procedures.

The theoretical part is short of what many readers will want. For example, the rate of a chemical reaction is stated to be proportional to the molarity "of each of the reactants raised to a power equal to the number of molecules or ions of that substance appearing in the balanced equation for that reaction." This statement may be correct, but to lead beginning students to believe that molecularity and order are always the same is hard to justify. Another example is found in the discussion of the computation of the hydrogen ion concentration of $NaHCO_3$ solutions. It is inferred that the hydrogen ion concentration of $NaHCO_3$ solution is computed solely from the hydrolysis of HCO_3^- instead of considering the sum of the hydrolysis and the ionization of HCO_3^- as an acid, or the disproportionation of HCO_3^- to give $[H^+] = \sqrt{K_1K_2}$. Other errors were not discovered, but many of the discussions are cursory.

Part Two contains satisfactory procedures for analysis of the conventional groups, but no experiments to make the student familiar with the properties of the individual ions precede the use of flow-sheet type of procedures. In Part Two there are some equations which are erroneous. On p. 214 there appears the "equation"

$$Mn^{2+} + O_2 \xrightarrow{OH^-} MnO_2$$

On p. 222, the authors say the blue substance formed in the vanishing blue test is H_3CrO_8. This material was shown not to exist thirty years ago although some salts of the acid are known. The blue substance is probably CrO_5 in which the oxidation state is +6. On the same page the startling "equation"

$$4H_3CrO_8 \rightarrow 4Cr^{3+} + 13O_2 + 6H_2O$$

appears without apology.

Part Two contains questionable procedures for saturating solutions with hydrogen sulfide.

The reviewer seriously questions whether the authors have accomplished their stated objectives in an outstanding way in contrast to comparable texts. Only use will tell.

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Spectroscopy. Volume 1, Atomic, Microwave, and Radio-Frequency Spectroscopy

S. Walker and *H. Straw*, both of the College of Technology, Leicester, England. The Macmillan Co., New York 1962. xix + 267 pp. Figs. and tables 16 × 25.5 cm. $9.

Spectroscopy. Volume 2, Ultra-Violet, Visible, Infra-Red, and Raman Spectroscopy

xvi + 386 pp. $12.

This subject is covered in two volumes which are designed to be independent. The volumes are directed to the beginning research worker who wishes a comprehensive view of the field and to spectroscopists having specialized experience and desiring information on branches of spectroscopy outside of this specialty. The authors are physical chemists and their treatment is largely directed to chemical rather than physical applications.

Volume 1 discusses atomic, molecular, and microwave spectra, as well as, electron spin and nuclear magnetic resonance. Molecular spectroscopy is not discussed in detail in this volume since it constitutes the major subject of Volume 2. Volume 2 contains chapters on molecular spectra including infrared, Raman and electronic and concludes with short chapters on phosphorescence, fluorescence, flames, and astrophysics, as well as applications of spectroscopic data in calculating force constants, dissociation energies, thermodynamic functions, etc. Almost every subject is illustrated by an experimental example and a brief description of the pertinent instrumentation.

Topics are treated very concisely but in considerable detail particularly with respect to spectral analysis. The classical approach is followed with results from quantum theory introduced as necessary. A minimum of theory is presented even in the appendices which give bare outlines of quantum mechanical treatments of such subjects as intensities, selection rules etc. At the end of each chapter, references to more advanced treatises are given but the references do not include some recent works of which the reviewer is aware. There are few errors of commission, the most obvious omission is the absence of any treatment of reflection spectroscopy. There are few typographical errors, the terminology used is generally rigorous, and mathematical symbols conform to general current practices. "Spectroscopy" in these volumes is understood to involve only electromagnetic radiation; subjects such as mass spectroscopy are omitted.

The volumes are not highly mathematical and require no more than a knowledge of the calculus. Spectra are considered primarily from the energy level point of view and extensive use is made of energy level diagrams. Considerable space is devoted to questions of coupling between orbital momentum and electron and nuclear spins. These sections are clearly written and well illustrated. The authors' attempt to show the correlations between the different branches of spectroscopy is quite successful.

These are not textbooks and they will probably be unintelligible to the reader without previous background in spectroscopy. They represent an intermediate level treatment of practical spectroscopy. Their use for supplemental and reference reading is to be recommended. Someone preparing for serious work in spectroscopy will require more information than is to be found in these volumes. However, anyone conversant with the subject matter as described here should be able to read current research papers in spectroscopy with considerable understanding.

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Organic Syntheses. Volume 42, 1962

Virgil Boekelheide, editor-in-chief. John Wiley and Sons, Inc., New York, 1962. ix + 118 pp. 15.5 × 23.5 cm. $4.25.

This latest volume of the series is once again a useful compilation of an array of organic reactions. The syntheses, 35 in number, range from the preparation of allene, a valuable chemical intermediate, to [2.2] paracyclophane, a compound of unusual geometry. The preparation of several compounds which can be used for specific purposes are included: among these are 3β-acetoxyetienic acid (resolution of alcohols), 2,4,5,7-tetranitrofluorenone (characterization of hydrocarbons), thiobenzoylthioglycolic acid (thiobenzoylating agent), and N-iodosuccinimide (iodination of enol acetates). Among the useful chemical intermediates whose syntheses are presented are tetrolic acid, 2-cyclopentenone, 2-cyclopentene-1,4-dione, ethylene sulfide and 2-norbornanone.

In general the syntheses require standard equipment and are not of the multistep, low yield variety. Twenty-four are scaled to give twenty or more grams of final product. The informative fourth section under each synthesis entitled Merits of Preparation now seems to be firmly established after appearing in some of the Volume 40 preparations and in all of those in Volume 41.

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Principles of Radioisotope Methodology

Grafton D. Chase, Philadelphia College of Pharmacy and Science, and *Joseph L. Rabinowitz*, University of Pennsylvania, Philadelphia 2nd. ed. Burgess Publishing Co., Minneapolis, Minnesota, 1962. viii + 371 pp. Figs. and tables. 22 × 28.5 cm. $6.

This revision of an earlier text by Chase is a considerably enlarged and greatly improved volume. As the title suggests, its main concern is with radioisotope laboratory techniques rather than with theoretical principles. However, most of the experiments are introduced with a brief treatment of the related theory and the detail is about as complete as could be expected in a volume of this type. More extensive use of diagrams, charts, and illustrations add to the attractiveness of this new edition. The clarity of the earlier work has been maintained, perhaps even somewhat improved.

Each chapter of the text contains a lecture outline and study guide, an introductory statement of principles, laboratory directions, and in most cases, references to the journal literature relating to the experiments.

An unusually comprehensive group of detection instruments and methods is discussed. These include: electroscopes, electrometers (with consideration of the vibrating reed electrometer), proportional, Geiger, windowless flow, neutron, scintilla-

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tion counters (including differential and integral methods) and liquid scintillation counters.

Radiochemical separation techniques considered are, precipitation methods, solvent extraction, chromatography, and ion exchange. Among the experiments dealing with radioisotopes in analytical, organic, and physical chemistry is a brief treatment of neutron activation analysis.

The appendices include: (1) Constants and Conversion Factors, (2) Glossary of Symbols, (3) Glossary of Nuclear Terms, (4) Table of Exponential Functions, (5) List of Reference Books, Periodicals, and Annual Reviews.

The earlier edition of this text was, everything considered, a clearly written and informative volume which was particularly useful to colleges and universities offering laboratory instruction in nuclear and radiochemistry courses. In this edition minor errors have been eliminated, the style smoothed out, and important additions made (for example, differential pulse height analysis). All in all Chase and Rabinowitz have done an admirable piece of work in the revision of this manual.

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Radioaktive Isotope in der Analytischen Chemie

L. M. Michejeva and *N. B. Michejev* (Moscow). Translated into German from Russian by *Hermann Jäger*, Merseburg. Edited by *Gisbert Grossmann*, Technical University, Dresden. Akademie Verlag, East Berlin, 1962. 100 pp. Figs. and tables. 16.5 × 24 cm. DM 13.0.

Quantitative analysis has long since evolved beyond the stage at which it employed only gravimetry, titrimetry, simple electrodeposition, and a few physical determinations such as density, refractive index, etc. Modern chemical analysis is characterized by the catholicity of its procedures; it gladly accepts techniques from any source and skillfully adapts them to its own needs. "The development of individual fields in chemistry and physics constituted the impulse for the creation of modern electrochemical and optical analytical procedures. The present vigorous growth of physics and engineering confronts the analyst with new problems but at the same time it provides him with a new aid—the radioactive isotopes." "This book presents a study of the most important fields of application of radioisotopes and radiations in analytical chemistry."

The principal topics included are treated in five main divisions. They are: determination of the solubility of slightly soluble compounds; coprecipitation processes and development of gravimetric analytical methods employing radioactive isotopes; quantitative methods based on the use of radioactive isotopes; physical methods of quantitative analysis by means of radioactive isotopes and emissions; activation analysis. Each of these broad fields is discussed in an exceptionally clear manner; little mathematics is used and only where its inclusion is obligatory; exceptionally good diagrams are provided; data are assembled into tables. References to the literature are adequate and include a number of languages. Though the titles of the Russian references are given in Cyrillic, the corresponding authors' names are printed in Roman and hence the abstracts can be run down without difficulty.

No directions are given for carrying out the various analyses but the operator should have no difficulty in devising a set of working procedures to fit the individual problems from the information provided by the text and the cited original articles. This is an excellent book and can be recommended for practicing chemists and advanced students. The price is reasonable.

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Chemistry of Carbon Compounds. Volume 5, Miscellaneous. General Index

Edited by *E. H. Rodd.* American Elsevier Publishing Co., New York, 1962. xviii + 912 pp. Figs. and tables. 15.5 × 23.5 cm. $29 single volume.

This volume concludes Dr. E. H. Rodd's comprehensive five volume series (actually ten separate books) on the "Chemistry of Carbon Compounds," publication of which was commenced in 1951. Organic chemists familiar with this series—as by now all must be—will recall that Volume 1 (two parts) treated Aliphatic Compounds, Volume 2 (two parts) Alicyclic Compounds, Volume 3 (2 parts) Aromatic Compounds and Volume 4 (three parts) Heterocyclic Compounds. The present and final Volume 5 consists of four miscellaneous chapters plus a 679-page general index to the entire series, totalling well over 55,000 separate entries. All in all, the ten parts to the complete series comprise almost 6000 pages of textual matter. Each separate part of the series, of course, has its own separate index, which totals over 670 pages for the first four volumes (nine parts). There is no Author Index to any of the volumes in the series.

The four miscellaneous chapters of the present volume treat the subjects of The Preparation and Use of Isotopically Labelled Organic Compounds, Natural Acetylenic Compounds, Developments in Carbohydrate Chemistry and The Structure of Proteins. The content of the first two chapters is self-explanatory from the titles. The last two chapters bring up to date the material published in 1952 in Chapters XX, XXI and XXII of Volume 1B of the series, summarizing new developments in these fields during the last decade.

It is particularly gratifying to see that this gargantuan effort of Dr. Rodd and his collaborators, begun well over a decade ago, has proceeded on schedule to full and successful fruition. The painstaking editorial care which has gone into the preparation of these volumes is attested by the total of a mere 174 corrections listed in the "Corrigenda" sheets which have accompanied the individual parts of Dr. Rodd's series. The sheet accompanying the present Volume 5 lists only 17 corrections to Volumes 4B and 4C. In past reviews of earlier volumes in this series [J. Chem. Educ., **30**, 158 (1953); **33**, 416 (1956); **34**, A242 (1957); **35**, 582 (1958); **37**, 163 (1960); **38**, 588 (1961)] this reviewer has expressed unqualified admiration for the well-organized, informative, well-documented and up-to-date chapters in Dr. Rodd's volumes. The present volume deserves a full measure of similar praise. There is no question that the "Chemistry of Carbon Compounds" series will remain *the* outstanding medium-sized compilation of organic chemistry for many years to come.

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Advances in Organic Chemistry: Methods and Results. Volume 3

Edited by *Ralph A. Raphael*, Glasgow University, Scotland; *Edward C. Taylor*, Princeton University, Princeton, New Jersey; and *Hans Wynberg*, Gronigen University, The Netherlands. Interscience Publishers (a division of John Wiley and Sons, Inc.), New York, 1963. vii + 333 pp. Figs. and tables. 15.5 × 23.5 cm. $13.75.

It has been said that success in organic synthesis, at least when a complex polyfunctional structure is the goal, lies largely in the management of "blocking groups." As the structure is elaborated, various reactive sites are "blocked" by simple reactions which convert them to unreactive functions from which the latent reactive sites can easily be liberated when needed. The challenge is to choose "blocking" or protective groups which can be installed or removed selectively.

In view of the importance of this problem, it is remarkable that no comprehensive review of protective groups had been published. This gap is now amply filled by two chapters in the present volume: Protective Groups, by J. F. W. McOmie, and Selectively Removable Amino Protective Groups Used in the Synthesis of Peptides, by R. A. Boissonnas. These complementary articles are both well done, and will be of great value to the professor as background for lectures and to the graduate student studying for cumulative examinations, as well as to the synthetic chemist.

D. M. Brown's chapter on Phosphorylation is a critical and comprehensive review of an important subject. Despite the recent appearance of other reviews on the same topic, it will have permanent value.

(*Continued on page A596*)

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It gives a large share of attention to the many valuable methods developed at Cambridge University.

R. I. Reed's article on Mass Spectrometry as a Structural Tool is of interest mainly for its "case study" presentation of methods for deducing the structures of complex molecules from mass spectra. The last 26 pages of a 70 page chapter are given to discussion of the mass spectra of 12 substances of natural origin, and the fascinating reasoning by which their structures can be inferred. Unfortunately the introductory 44 pages are not well utilized. For example, it was unnecessary to say: "In [the steroid and triterpene] series, particularly with the hydrocarbons, it is difficult to decide the molecular complexity of the compound by conventional combustion analysis." The reader approaching this subject for the first time is advised to read Flett's chapter on Mass Spectrometry (in "Physical Aids to the Organic Chemist," Elsevier, 1962) as an introduction to Reed's case studies.

This is a slim volume at a high price, but its purchase is a "must" for libraries. Personal acquisition should be seriously considered by affluent chemists interested in organic synthesis.

JOSEPH F. BUNNETT
Brown University
Providence, Rhode Island

Mass Spectrometry: Organic Chemical Applications

Klaus Biemann, Massachusetts Institute of Technology. McGraw-Hill Book Co., Inc., New York, 1962. xii + 370 pp. Figs. and tables. 16 × 23.5 cm. $13.75.

The organic chemist concerned with compound identification and structural studies has long been familiar with empirical interpretation of infrared and ultraviolet spectra; and in recent years, he has learned to make effective use of nuclear magnetic resonance spectrometry. It seems remarkable, therefore, that he has almost completely ignored mass spectrometry which in many cases is the most powerful tool available to him.

Mass spectrometry has been utilized extensively by physical chemists, petroleum chemists, and physicists. Perhaps it was inevitable that the first book on the subject that clearly pointed out the potential in organic chemistry was written by a physicist, J. H. Beynon ("Mass Spectrometry and Its Application to Organic Chemistry," Elsevier Publishing Co., 1960). Beynon's book is monumental and completely authoritative, and will probably be the basic reference for the professional spectrometrist for some time to come. But only a few organic chemists have received the message.

With the recent advent of K. Biemann's book, the organic chemist no longer has any excuse for his indifference to, or ignorance of, mass spectrometry. Biemann is an organic chemist, and he speaks enthusiastically, insistently, and lucidly to all organic chemists involved in compound identification and structural determination. The only hiding place left is behind the laboratory budget. However, if instrument manufacturers perform in this area as they have in others, the mass spectrometer may eventually take its place as a bench instrument.

In addition to convincing the unenlightened of the potentialities of mass spectrometry, Biemann has brought the insight of an organic chemist to rationalize fragmentation patterns. Further, he has dispelled the common misconception that mass spectrometry is not applicable to complex molecules.

There is nothing at all to criticize in this elegant book. But another point of view can be presented in several situations. Biemann does not include a table of masses and isotope abundances. Instead he presents simplified calculations for predicting isotope abundances from the empirical formula. In practice, however, the usual problem is to derive an empirical formula from isotope abundances, and the table in Beynon's book is extremely useful for this purpose. It is true that Beynon's tables are useful only up to moderate molecular weights (mass 250 or so), and Biemann's own research has been largely concerned with complex molecules.

Biemann shows his fragmentations as graphs. The reviewer prefers a tabular presentation which gives a quick grasp of the exact mass-numbers, and is certainly easier to prepare.

A table of common fragments would be convenient for the uninitiated.

R. M. SILVERSTEIN
Senior Organic Chemist
Stanford Research Institute
Menlo Park, California

Selected Papers

Kaj Linderstrøm-Lang. Academic Press, Inc., New York, 1962. 584 pp. Figs. and tables. 16 × 24 cm. $17.

A group of colleagues of the late Kaj Linderstrøm-Lang have compiled this book as a memorial to a fine scientist and a remarkable man. As the editors remark in their foreword, they have selected these particular papers "either because of their particularly lasting value or because they have been previously published in less-accessible scientific journals."

If the papers had been selected to demonstrate the versatility of Linderstrøm-Lang, they could scarcely have been better chosen. We see the author as a theoretical physical chemist, discussing salting-out effects, as a resourceful experimentalist, designing dilatometric methods for microanalysis, as a protein chemist studying denaturation, molecular weights, conformation, and isotope exchange, as a philosopher setting down his views on man, machines, and the purpose of life in the essay "New Year 1957," and as a hilarious humorist in the famous "Thermodynamic Activity of the Male Housefly."

Each of the papers is a little masterpiece and the book is highly recommended, both for the intrinsic value of the material and for the charming style of presentation. It will be particularly appreciated by those who are fond of classical physical chemistry, of which the author was a master.

The papers, which are arranged chronologically, from 1923 onward, are all in English except for one in German.

PETER OESPER
Hahnemann Medical College
Philadelphia, Pennsylvania

Progress in Microscopy. Volume 9

M. Françon, The Sorbonne. Harper and Row New York 16, N. Y. 1961. vii + 295 pp. Figures. 15.5 × 23.5 cm. $9.

For the microscopist and particularly the casual user of the microscope, it has often been stated that the understanding of the optics is more important than the metal hardware associated with the microscope. This situation is particularly true today with the profusion of sophisticated optical devices that have been developed to translate otherwise invisible phase shifting, or infrared and ultraviolet absorbing features of an object into visibly distinguishable structural details. Unless the optical principles are understood, the relationship of the image to the structure producing the image is hopelessly confused.

"Progress in Microscopy," or more appropriately "Progress in Microscope Optics," fulfills the need for a better understanding of the complex optics of modern microscopes. Professor Françon has very ably and lucidly described most of the recent major developments in microscope optics for ultraviolet, visible and infrared light. The material is presented simply and yet basically as one would expect by a competent teacher of physics and light optics. Emphasis is on general optical principles. These are profusely illustrated with simple diagrams and a minimum of mathematical development.

The basic results obtained with the various optical devices are described. These results and their photographic confirmation could possibly have been expanded for those of us who appreciate the importance of optics but also are interested in the application of these devices to the solution of our day to day problems. Such, however, was beyond the intended scope of the author. As Volume 9 of "Modern Trends in Physiological Sciences" the few applications described are mostly for the biological specimen. These do not detract however from the usefulness of the volume for the student of other fields.

"Progress in Microscopy" is very logically developed with an extended first chapter survey of image formation starting with the image of a pinpoint light source and followed by an examination of extended objects. Subsequent chapters cover phase contrast, interference, reflected light, geometrical and physical measurements, infrared and ultraviolet,

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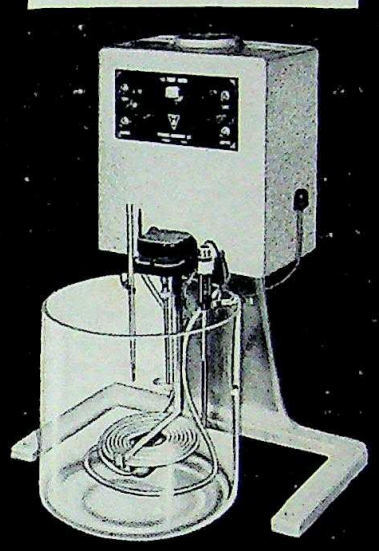

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and microspectroscopy and microspectrophotometry. A final chapter entitled "Chemical Microscopy," describing the fusion methods of the Koflers, although a major microscopical development somehow is not in keeping with the previous portions of the book.

This monograph is a timely collection and review of the numerous novel optical devices made available during the past twenty years for the examination of microscopical objects. It is a convenient reference for the more serious student of modern trends in microscopical techniques and instrumentation.

CHARLES MARESH
Research Laboratories
American Cyanamid Company
Bound Brook, New Jersey

New Volumes in Continuing Series

The following titles are those of volumes in continuing series. Many of these series are familiar to readers, who are best served by prompt announcement of the appearance of new titles. The policy of THIS JOURNAL will be to publish full reviews only of inaugural volumes in new series. The publication of later volumes will be announced in this column. Full bibliographic information will be supplied as well as a list of contributing authors.

Advances in Carbohydrate Chemistry. Volume 17

Edited by *Melville L. Wolfrom*, Ohio State University, Columbus, and *R. Stuart Tipson*, National Bureau of Standards, Washington, D. C. Academic Press, Inc., New York, 1962. xi + 503 pp. Figs. and tables. 16 × 23.5 cm. $16.

Contributors: J. M. Webber; T. Reichstein and Ekkehart Weiss; R. W. Bailey and J. B. Pridham; K. Heyns and H. Paulsen; Olof Theander; John A. Montgomery and H. Jeanette Thomas; D. J. Manners.

Advances in Fluorine Chemistry. Volume 3

Edited by *M. Stacey* and *J. C. Tatlow*, both of the University of Birmingham, England, and *A. G. Sharpe*, University of Cambridge, England. Butterworth, Inc., Washington, D. C., 1963. 281 pp. Figs. and tables. 16 × 25.5 cm. $9.95.

Contributors: H. P. Braendlin and E. T. McBee; H. C. Clark; R. E. Parker; C. B. Colburn; J. M. Hamilton, Jr.; A. K. Barbour, L. J. Belf, and M. W. Buxton.

Advances in Protein Chemistry. Volume 17

Edited by *C. B. Anfinsen, Jr.*, Harvard Medical School, Boston, *et al.* Academic Press, Inc., New York, 1962. xvi + 412 pp. Figs. and tables. 16 × 23.5 cm. $14.

(*Continued on page A598*)

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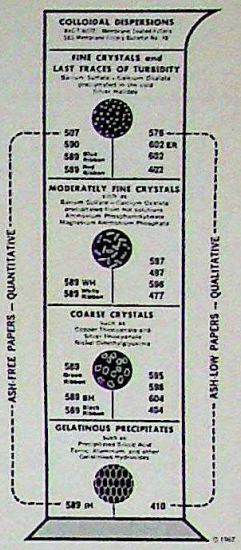

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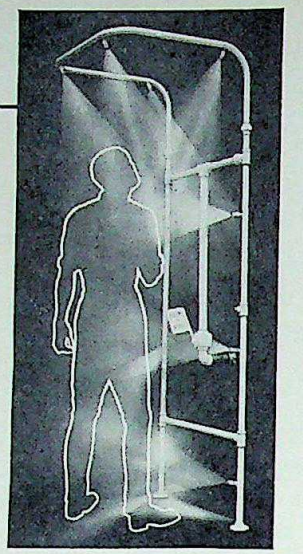

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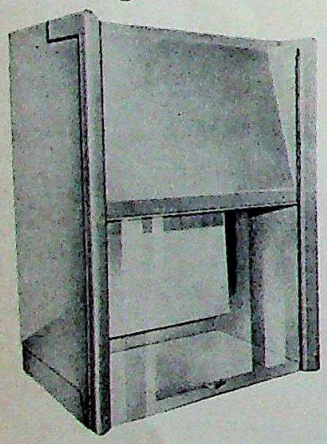

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Contributors: S. J. Singer; Charles Tanford; F. Sörm and B. Keil; Jerker Porath; S. M. Partridge; D. B. Wetlaufer.

The Harvey Lectures. Series 57

Delivered under the auspices of the Harvey Society of New York, 1961–62. Academic Press, Inc., New York, 1962. xiv + 204 pp. Figs. and tables. 14 × 21 cm. $9.50.

Contributors: Christopher H. Andrewes; Bernard L. Horecker; Joel Elkes; P. F. Scholander; Kenneth B. Raper; Eugene P. Kennedy.

Vacuum Microbalance Techniques. Volume 3

Edited by *Klaus H. Behrndt*, Bell Telephone Laboratories, Murray Hill, New Jersey. Plenum Press, New York, 1963. xvi + 215 pp. Figs. and Tables. 16 × 23.5 cm. $9.50.

Contributors: J. A. Poulis and John M. Thomas; Lee Cahn and Harold R. Schultz; Th. Gast; A. W. Warner and C. D. Stockbridge; H. Mayer, R. Niedermayer, W. Schroen, D. Stünkel and H. Göhre; A. L. Houde; D. Shooter; H. L. Gruber and C. S. Shipley; N. J. Carrera, R. F. Walker, C. A. Steggerda, and W. M. Nalley; E. A. Gulbransen, K. F. Andrew, and F. A. Brassart; Y. Ohman and B. Rydgren.

International Review of Cytology. Volume 14

Edited by *G. H. Bourne*, Emory University, Atlanta, Georgia, and *J. F. Danielli*, University of Buffalo, Buffalo, New York. Academic Press, Inc., New York, 1963. ix + 414 pp. Figs. and tables. 16 × 23.5 cm. $16.

Contributors: Seymour Gelfant; R. Buvat; J. A. Vinnikov and L. K. Titova; R. E. Mancini; D. H. Northcote; Mary Barber; Cecilie Leuchtenberger and Rudolf Leuchtenberger; Douglas E. Smith.

Biochemical Frontiers in Medicine

Edited by *Harris Busch*, Baylor University College of Medicine, Houston, Texas. Little, Brown, and Co., Boston, 1963. x + 364 pp. Figs. and tables. 16 × 24 cm. $12.50.

Contributors: Harris Busch; William L. Nyhan; Oscar Bodansky; Robert E. Parks, Jr.; Emmanuel Farber.

Residue Reviews. Volume 2

Edited by *Francis A. Gunther*, University of California, Riverside. Academic Press, Inc., New York, 1963. 156 pp. Figs. and tables. 16 × 23.5 cm. $6.50.

Contributors: A. L. Taylor; M. E. Getz; P. H. Martens and P. Nangniot; J. W. Mitchell and P. J. Linder; C. H. van Middelem; R. C. Blinn and F. A. Gunther.

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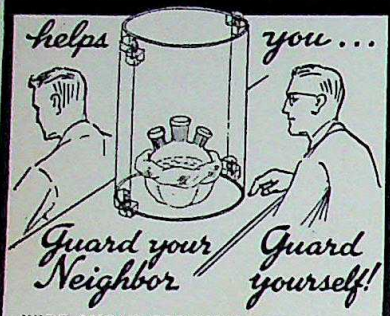

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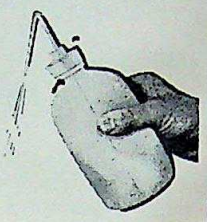

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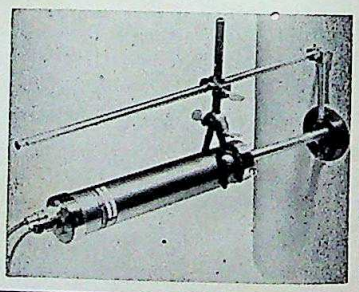

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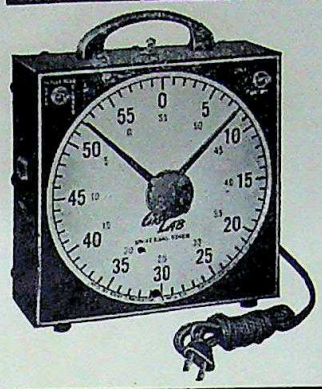

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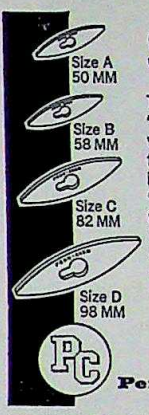

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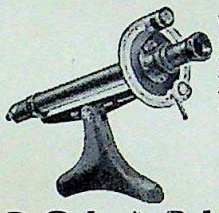

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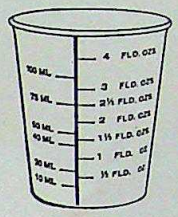

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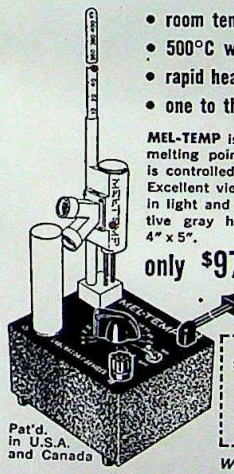

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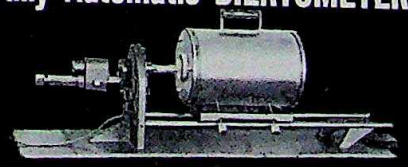

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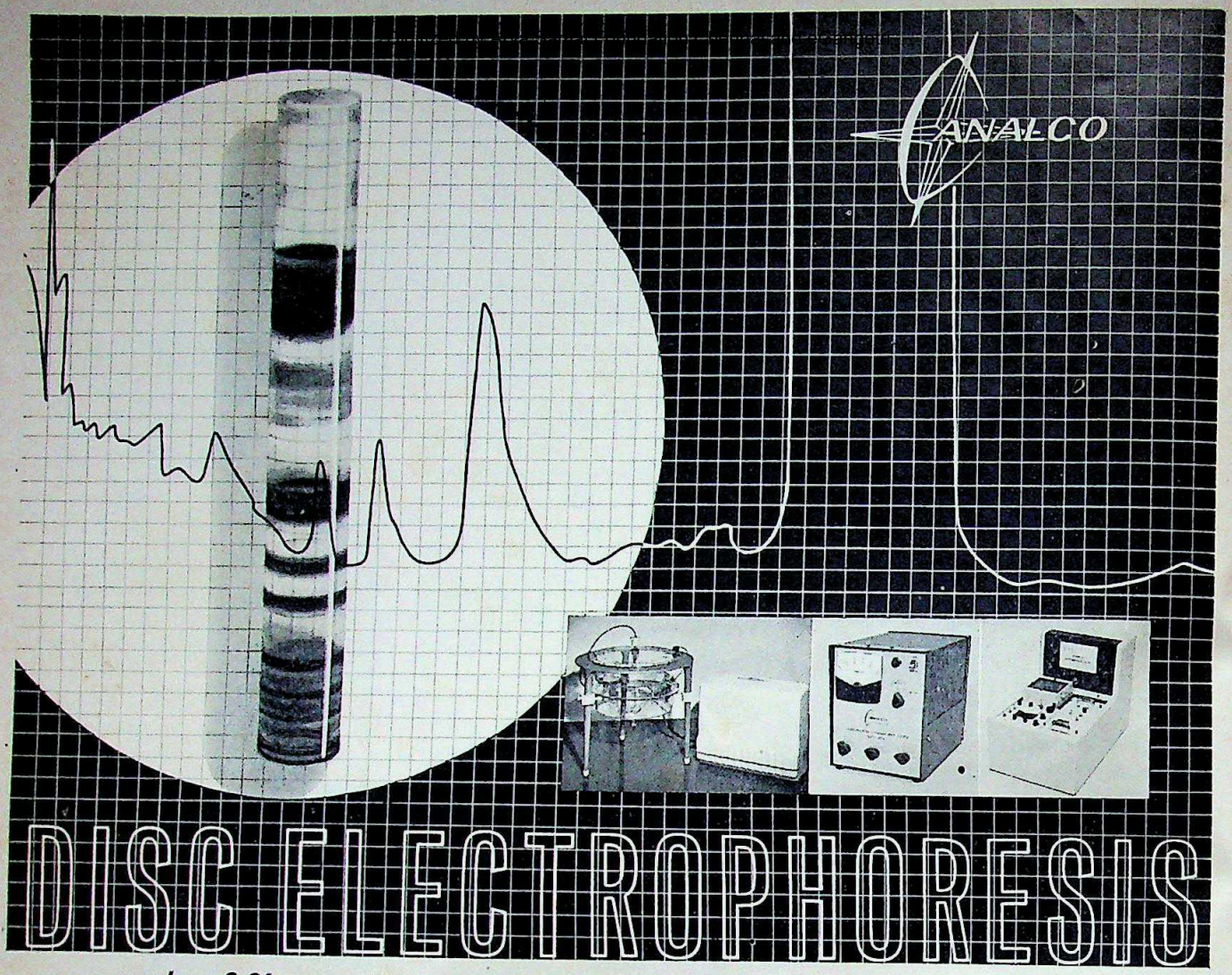

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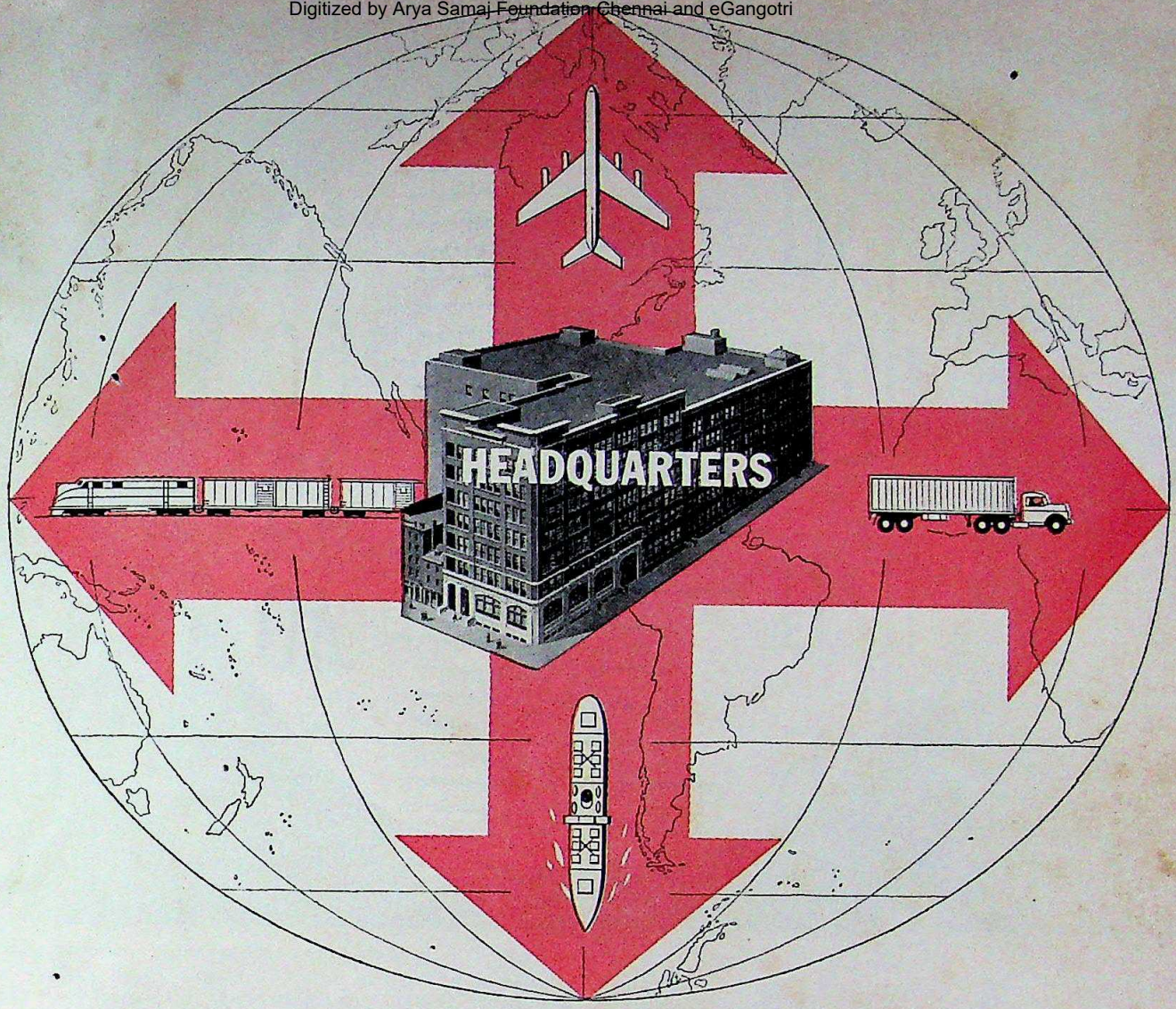

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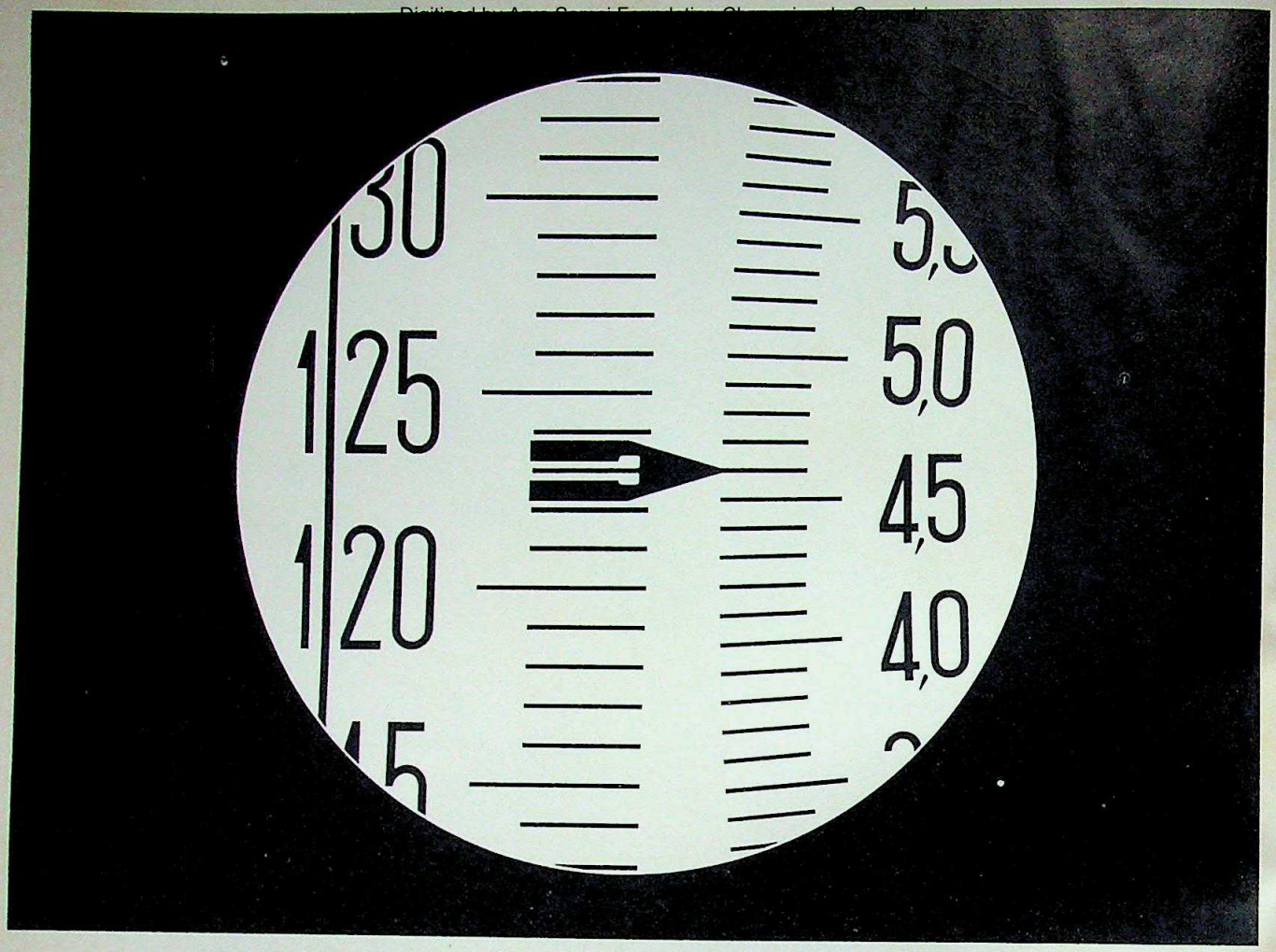

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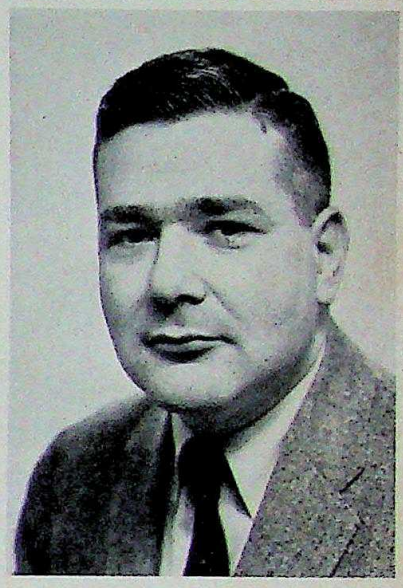
These articles, most of which are to be contributed by guest authors, are intended to serve the readers of this JOURNAL *by calling attention to new developments in the theory, design, or availability of chemical laboratory instrumentation, or by presenting useful insights and explanations of topics that are of practical importance to those who use, or teach the use of, modern instrumentation and instrumental techniques.*

XII. Pressure Measurement. Part One

Seymour T. Zenchelsky, *School of Chemistry, Rutgers University, New Brunswick, N. J.*



S. T. Zenchelsky is Associate Professor of Chemistry at Rutgers University. He was educated at New York University (B.S., 1941; M.S., 1947; Ph.D., 1952). He teaches and does research in analytical and physical chemistry.

Various devices are used for the measurement of pressure, depending chiefly on the pressure range of interest and the precision desired. Since most work in chemistry involves pressures below atmospheric, this series will restrict itself accordingly. Despite this fact, the number of pressure-measuring devices is still quite large (*1*). Thus it will be necessary to further limit these articles to those devices which are readily available commercially. Obviously, a very useful classification would be based upon the applicable pressure range, such as is shown in Figure 1. However, in the interests of orderly exposition and the avoidance of repetition, the following discussion will be arranged primarily according to the principle of measurement involved.

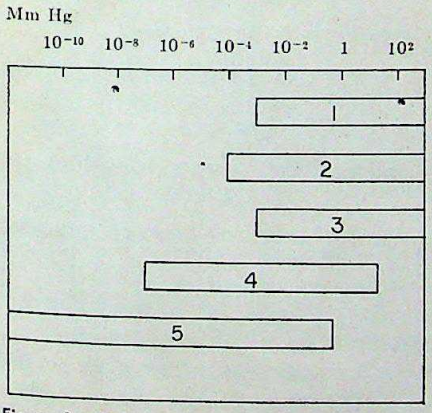


Figure 1. Ranges of applicability of commonly used types of pressure-measuring devices (approximate): (1) U-tube Manometers; (2) Mechanical Gages; (3) Thermal Gages; (4) McLeod Gages; (5) Ionization Gages.

Three basic methods have been used. The first consists of observing the height of a liquid column, usually mercury. A very familiar example is the simple U-tube manometer, but many variations are known. The second method involves the distortion of a solid surface and is usually followed by observing the displacement of a pointer attached to it. This is the Bourdon-gauge principle, and many designs based upon it have been described. However, most numerous are those devices which depend upon observation of the kinetic-molecular behavior of gases (*1*). This third method utilizes such properties of gases as viscosity, heat conductance, ionization, or compressibility, as a means for deducing the pressure. Of the three methods, only the last one is absolute; i.e., the pressure may be calculated from the gas properties if all the required parameters are known. In practice, however, these are not always available. On the other hand, while the first two are really differential methods, they are frequently used for the indication of absolute pressure. As will be shown, this procedure usually represents a very good approximation in practice.

Liquid-Column Gages

U-tube Manometer. The difference between the levels of two interconnected columns of liquid is directly proportional to the difference between the pressures exerted upon them, assuming equal capillary effects in both tubes. Thus, by connecting one end (the reference end) of the U tube to a vacuum (zero pressure), the manometer becomes an absolute device. In fact, for practical purposes, it is only necessary that the pressure at the reference end be very much smaller than the one being measured at the other end. But this goal is impossible to achieve if a manometric liquid with high vapor pressure is used, particularly if very low pressures are to be measured. Therefore, mercury is generally employed even though greater sensitivity is obtainable with liquids of lower density.

In this series—according to common practice—the unit of absolute pressure will be taken as that exerted by a one-millimeter column of mercury under standard conditions and will be designated by the symbol, mm Hg. In operational terms, this unit corresponds to a *difference* in column-heights of one millimeter of mercury. If another manometric liquid is used (assuming that its vapor pressure is negligible), the difference in observed column-heights, in millimeters, can be converted to mm Hg by multiplying by the factor, $\text{Density}_{\text{liquid}}/\text{Density}_{\text{Hg}}$. The vapor pressure of mercury is 10^{-3} mm Hg at 20°C; that for water is 17.5 mm Hg at 20°C.

Commercially available, absolute U-tube manometers have one end sealed off and are filled with mercury under "vacuum" (less than 0.01 mm Hg). These as well as the open-end (differential) type are available from almost all laboratory-supply houses and manufacturers of chemical glassware. One disadvantage of closed-end manometers is the fact that cleaning and refilling with mercury are quite difficult. For this reason, several designs are available which permit simple opening and positive resealing of the reference end.

In the RGI Manometric Gage (Roger Gilmont Industries, Inc., New York, N. Y.), mercury is drawn up into the reference end which is then closed off by

(*Continued on page A612*)

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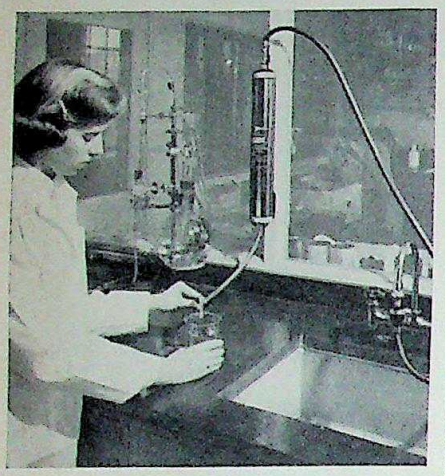

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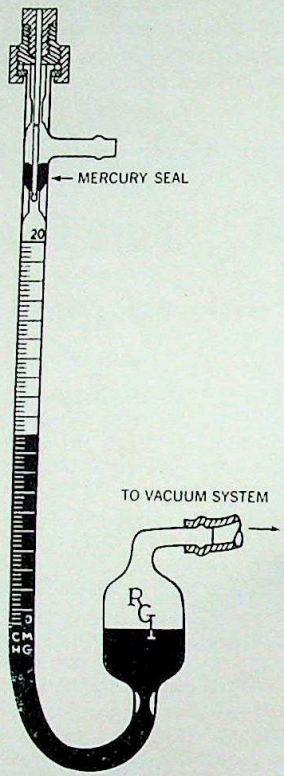

Fig. 2. RGI Positive Closed-End Manometric Gage.

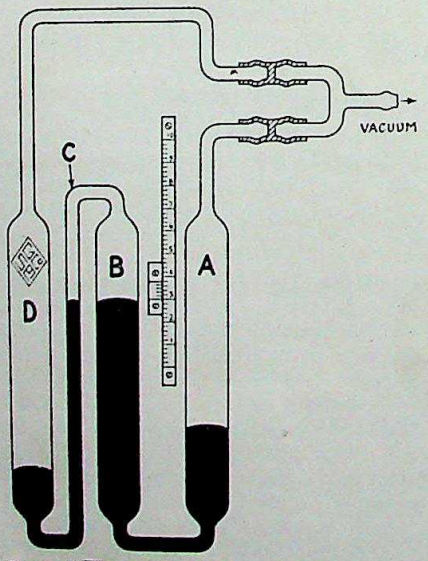

Figure 3. SGA Zimmerli Gage (with "vacuum" between the U-tubes for absolute-pressure measurement).

(*Continued on page A614*)

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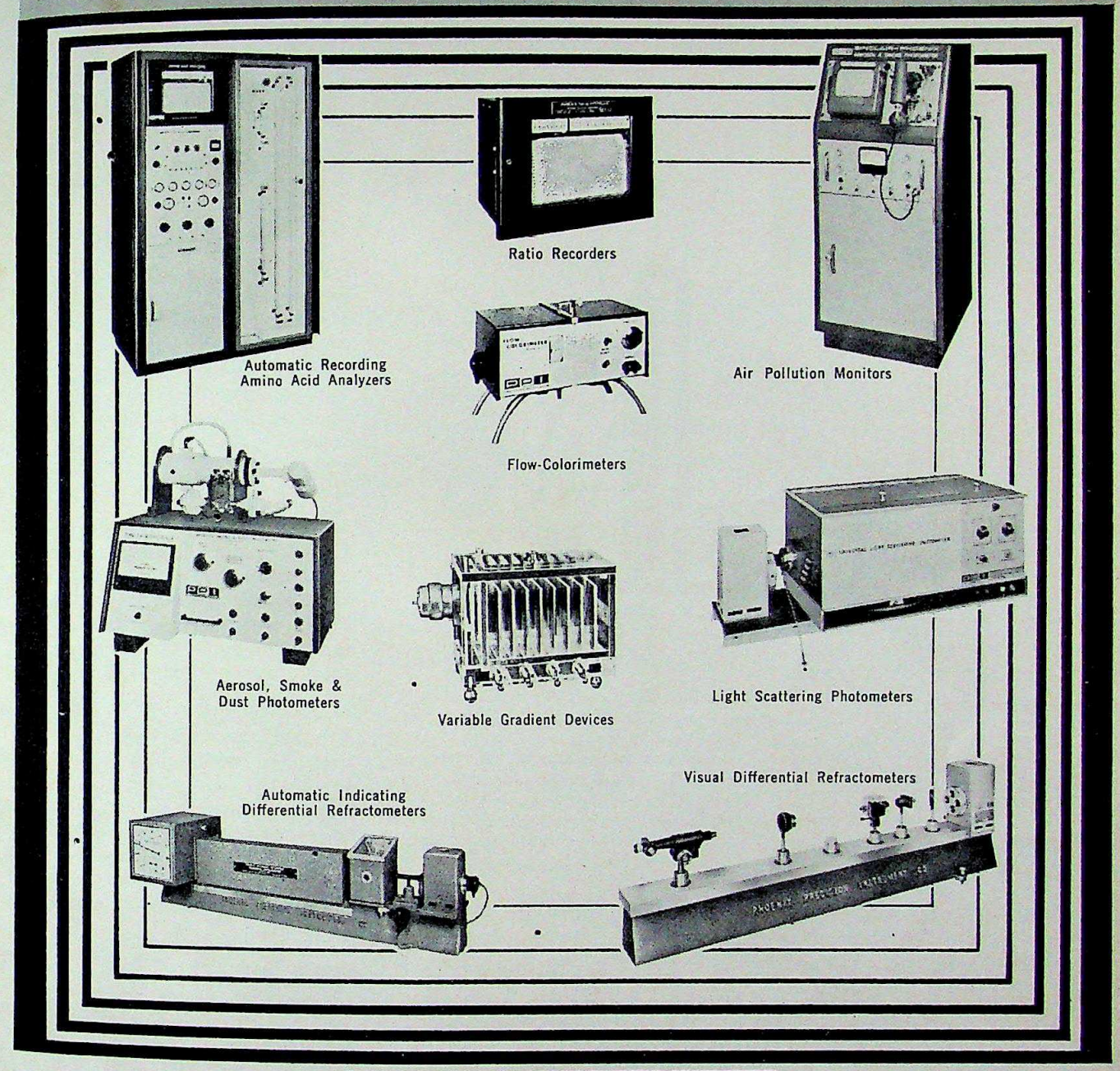

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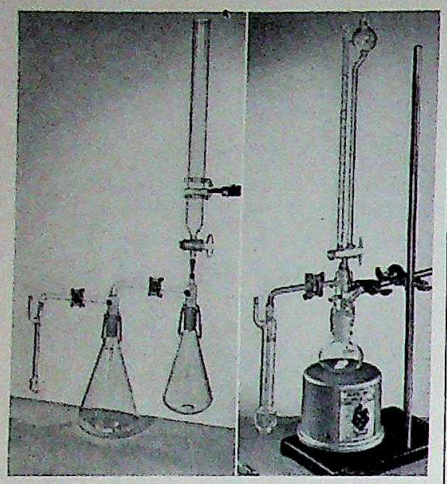

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It is filled, under vacuum, in the horizontal position so that a continuum of mercury is present in all four legs (Fig. 4). When placed in the vertical position, the continuum is automatically broken between the U-tubes, leaving an evacuated space as shown in Figure 3. Upon opening the gage to the atmosphere, the continuum is reformed (Fig. 4). For absolute measurements, both ends are connected to the system and the right-hand U-tube is read. The function of the left-hand U-tube is merely that of sealing off the reference end of the right-hand U-tube. For differential measurements, only one U-tube is filled with mercury in the conventional manner. Several models are available; the Precision Model has a range of 100 mm, readable to 0.1 mm.

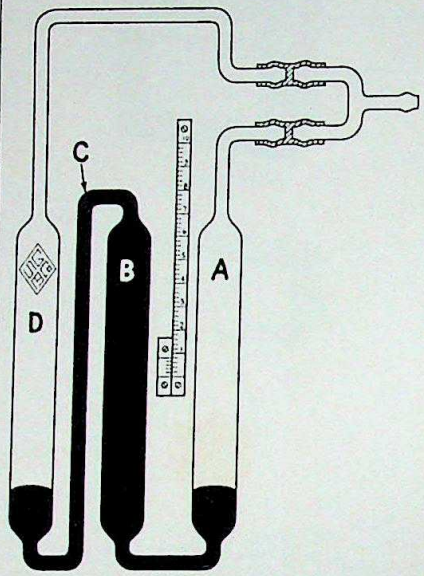


Figure 4. SGA Zimmerli Gage (with mercury continuum—in the horizontal position during filling).

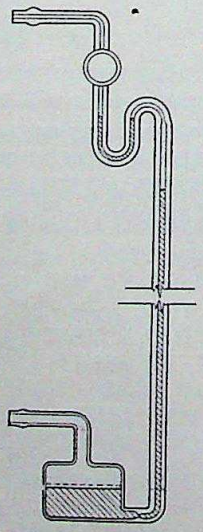
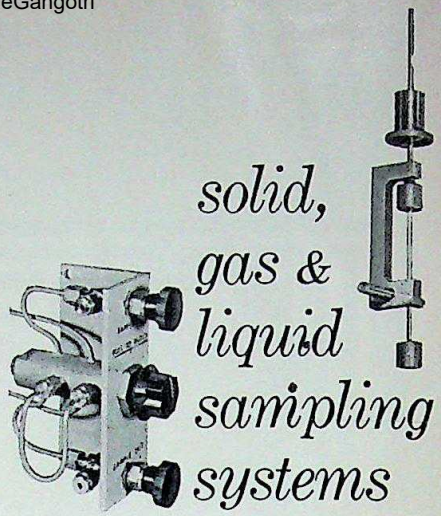


Figure 5. Manostat Absolute and Differential Manometer.

(*Continued on page A616*)



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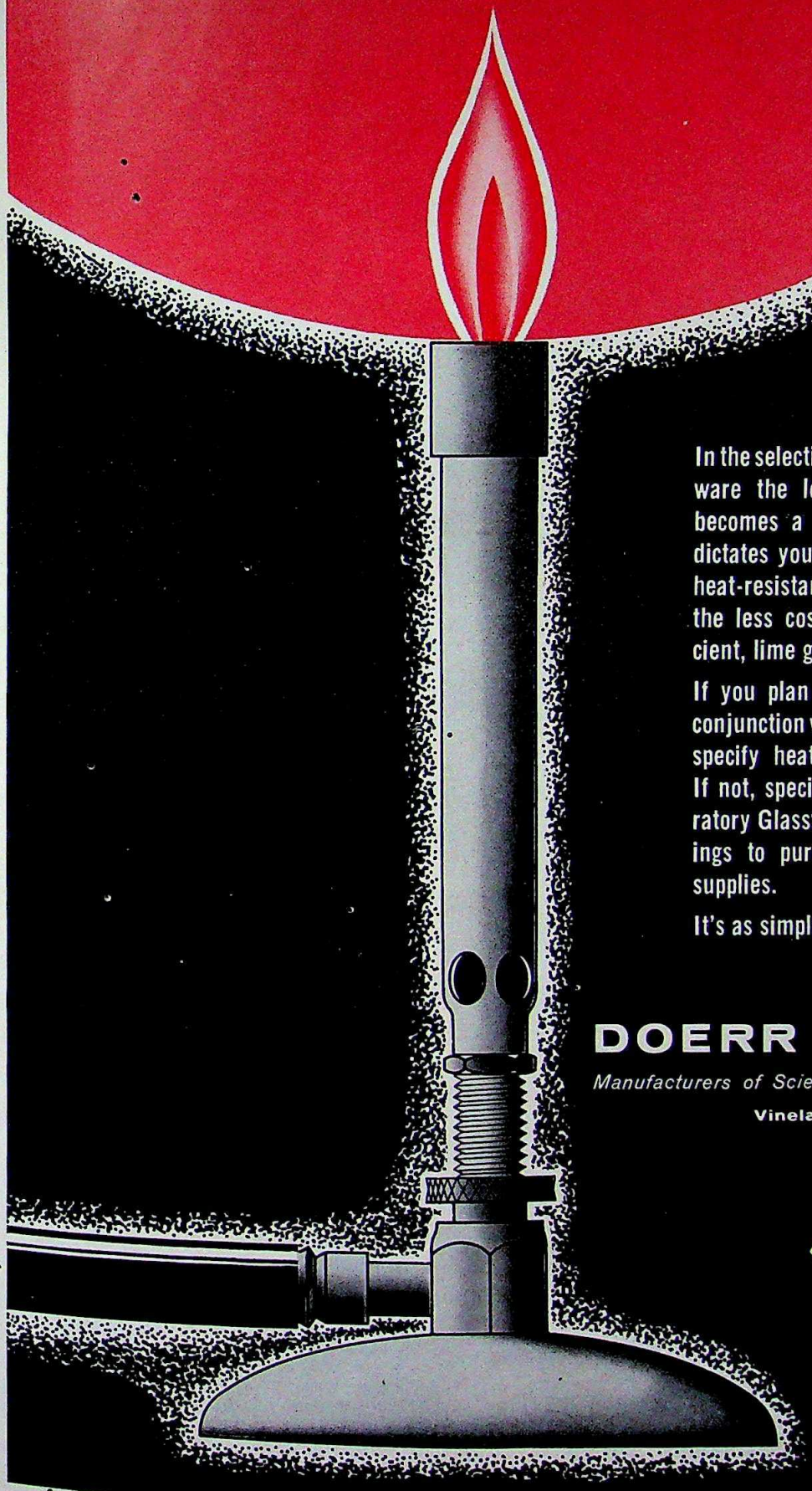

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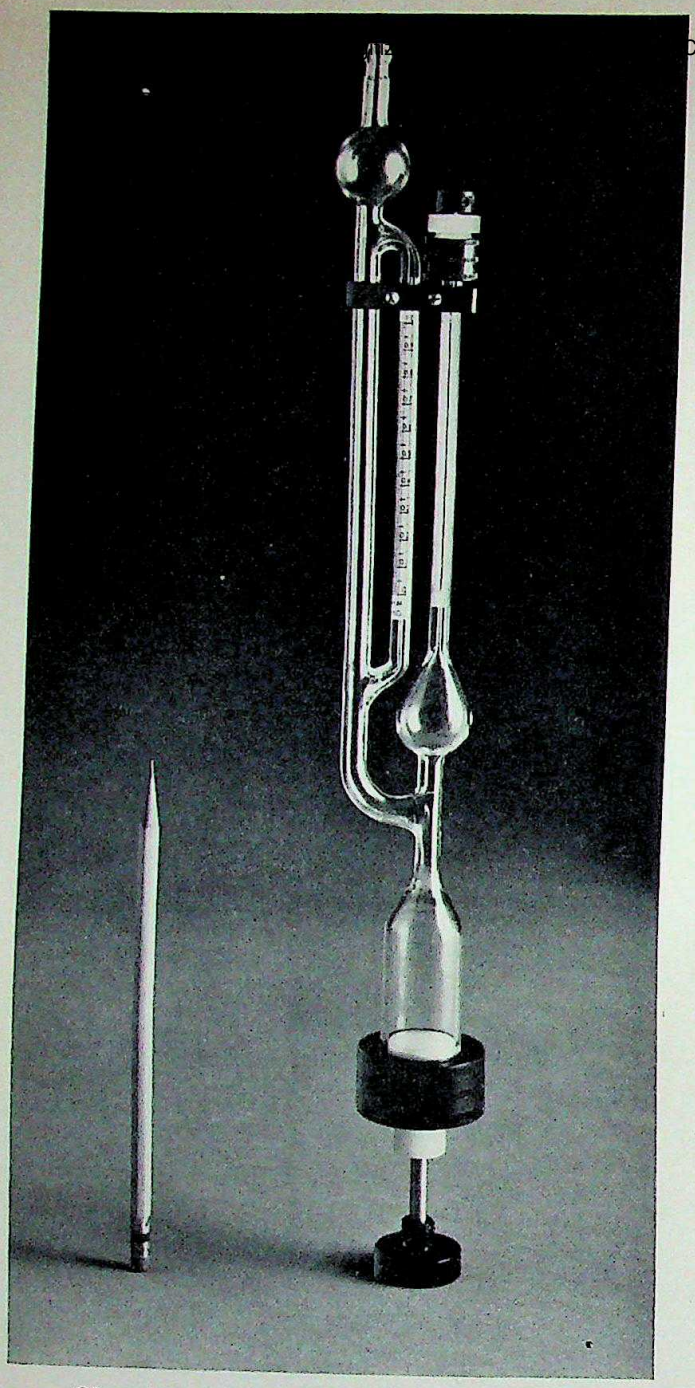

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A very similar design is available as the Cenco 94122 Manometer (Central Scientific Co., Chicago, Ill.), but this device cannot be used for differential measurements. Still another design, utilizing a variation of the same principle, is found in the Manostat Manometer (Manostat Corp., New York, N. Y.) which is shown in Figure 5. It is available in two ranges, 0–200 mm and 0–800 mm, both readable to 0.1 mm.

An increase in sensitivity would permit more precise differential readings as well as the measurement of lower absolute pressures (provided that the "vacuum" at the reference end were very good). Toward this goal, numerous devices have been used, including cathetometers, optical levers, and displacement transducers of various kinds (*1*). Some of these are available—or may be obtained on special order—from makers of precision glassware, such as Eck and Krebs (Long Island City, N. Y.). The RGI Micrometric Manometer, which is shown in Figure 6,

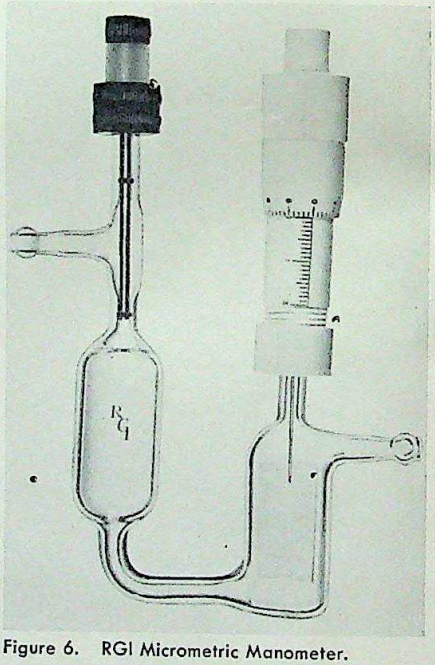

Figure 6. RGI Micrometric Manometer.

employs a micrometer drive to bring a stainless-steel needle into accurate contact with the top of a mercury column. Changes in the mercury level can then be estimated to the nearest 5×10^{-4} inches (1.3×10^{-2} mm). The total range is approximately 50 mm. Of course, the sensitivity of all of the preceding devices can be increased by using a manometric liquid of lower density, subject to the limitation on vapor pressure previously mentioned.

Cartesian Manometer. Dubrovin (*2*) has described a manometer based on the Cartesian-diver principle. Such gages consist of a mercury-containing outer tube in which there floats a thin-walled glass tube. The float is open at the

(*Continued on page A618*)

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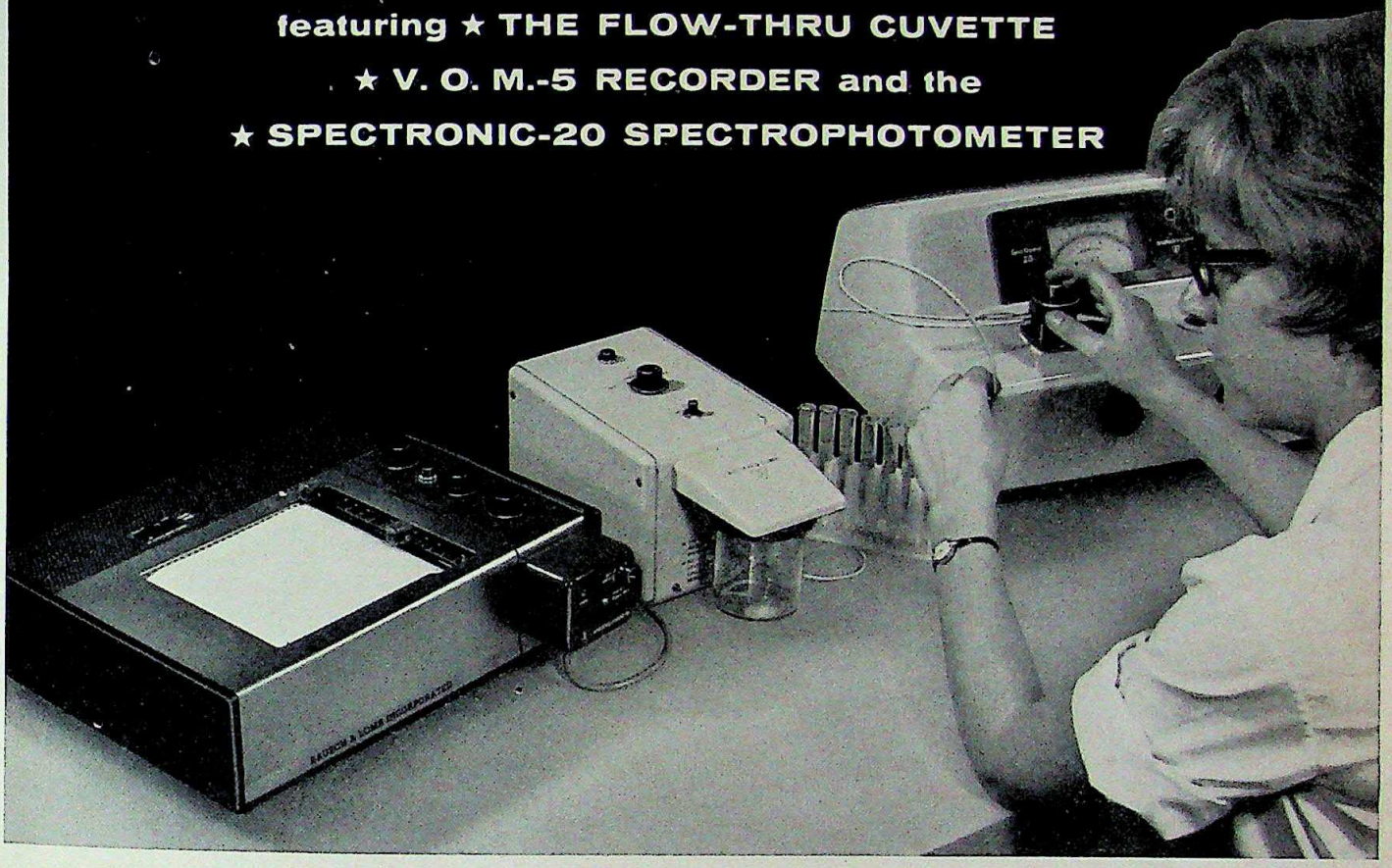

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bottom and is centered in the outer tube by means of loose-fitting guides. If both the float and the outer tube are evacuated, the top of the float will be near the zero mark of Figure 7. If the outer tube is

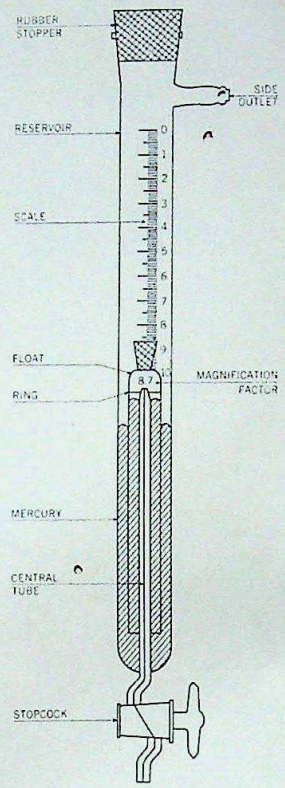

Figure 7. Manostat Cartesian Manometer.

then opened to the atmosphere, the mercury will rise into the float, thereby lowering its buoyancy and causing it to sink to the bottom of the outer tube. Germann and Gagos (*3*) have given a theoretical treatment of the principle of operation. They showed that the linear displacement of the float depends upon its diameter and wall thickness. Thus, for very thin-walled floats, it is possible to obtain a displacement of 100 mm for a pressure change of only 10 mm Hg.

Such gages are available from Roger Gilmont Industries and from Manostat Corp. The former features easy zero-setting while the latter is usable for both differential and absolute pressure measurement. Both of these gages present the pressure range, 0–10 mm Hg, on a scale of 100 mm which is graduated in one-millimeter divisions. A very sensitive version of this device is the Betz Micromanometer (*Instrumentfabriek Van Essen N.V., Delft*, available from Epic, Inc., New York, N. Y.). It utilizes water as the manometric liquid, an extremely thin-walled float, and optical projection for further magnification of 20 diameters. Two models are available, one covering the range 0–250 mm H_2O (approx. 19 mm Hg) and the other covering the range

(*Continued on page A620*)

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0–500 mm H_2O (approx. 38 mm Hg). The former can be estimated to the nearest 0.001 mm Hg and the latter to the nearest 0.002 mm Hg. Since the vapor pressure of water at 20°C is about 17 mm Hg, this instrument is useful only as a differential device.

McLeod Gage. Although the height of a liquid column is observed, the McLeod gage actually belongs to the third category of pressure-measuring devices—those depending on the kinetic-molecular behavior of gases. It is thus a true absolute-device. As shown in Figure 8,

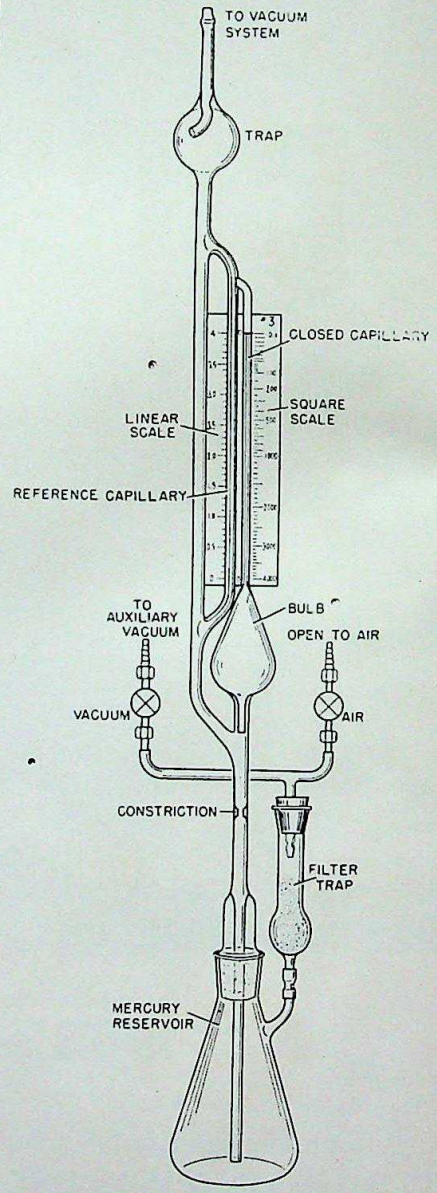

Figure 8. Manostat High Precision McLeod Gage.

the gage consists of a mercury-reservoir flask connected to the vacuum system by means of a large-diameter tube (left). This tube contains a capillary bypass (center tube) and is also connected to a bulb (right) which terminates in a closed-

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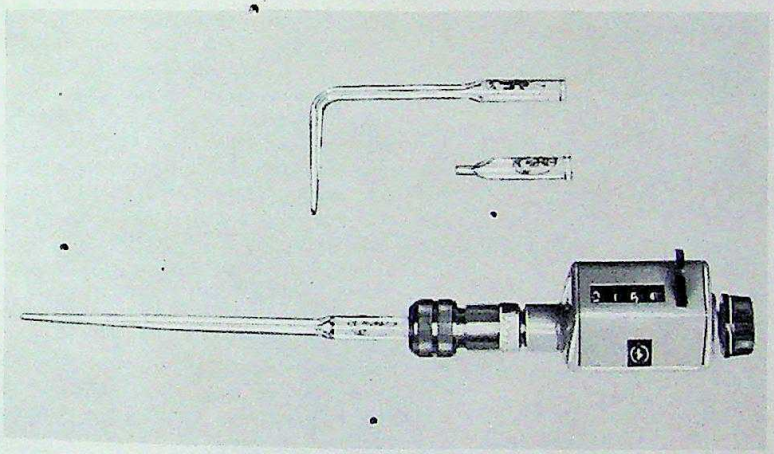

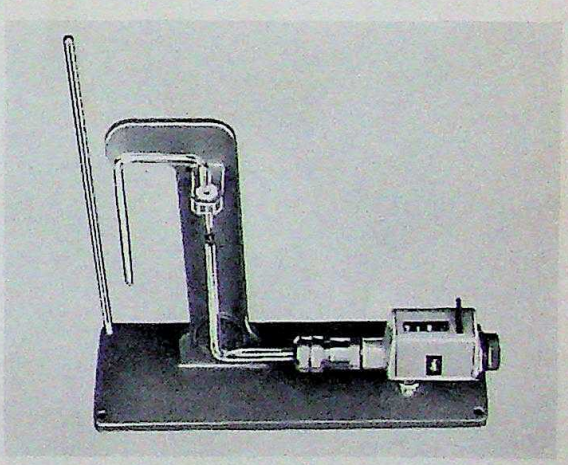

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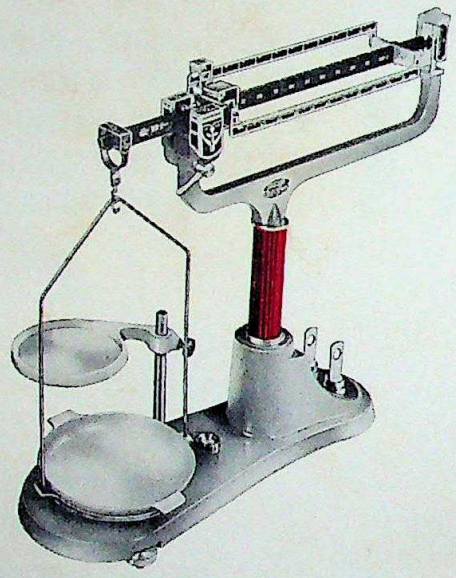

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end capillary. The bypass has the same bore as the closed-end capillary, and its sole function is that of cancelling the effects of capillarity on the measurement. In operation, a known volume of gas at the system pressure is compressed to a much smaller known volume and the resulting change in pressure is determined by observing the difference in mercury-levels between the bypass and closed-end capillaries. The system pressure can then be calculated by means of Boyle's law. Usually, however, the closed-end capillary is graduated directly in absolute pressure. Because the McLeod gage depends upon compression, the pressure of condensable vapors, e.g., water, ammonia, or mercury, cannot be measured.

Since the initial volume is determined chiefly by the size of the bulb, and the final volume by the size of the closed-end capillary, the range of measurement can be altered by altering the sizes of either or both of those parts. McLeod gages are available in various ranges from suppliers of chemical glassware, who will also custom-fabricate special designs. Typical ranges are: 5×10^{-7} to 5×10^{-2} mm Hg, 10^{-5} to 10^{-1} mm Hg, and 10^{-2} to 20 mm Hg. The scale is nonlinear because the measured pressure is proportional to the square of the difference in mercury levels; but by means of a slight variation in the measuring procedure, a portion of the range can be presented on a linear scale. Thus on the Manostat High Precision McLeod Gage (Fig. 8) which has a square scale covering the range 5×10^{-6} to 2×10^{-1} mm Hg, there is also a linear scale covering the range 5×10^{-3} to 2×10^{-1} mm Hg.

In the conventional McLeod gage, mercury is kept from rising into the large-diameter tube and capillaries by connecting the reservoir-flask to an auxiliary vacuum. Then the mercury is permitted to rise by bleeding air into the flask, thus compressing the gas in the closed-end capillary to its final known volume.

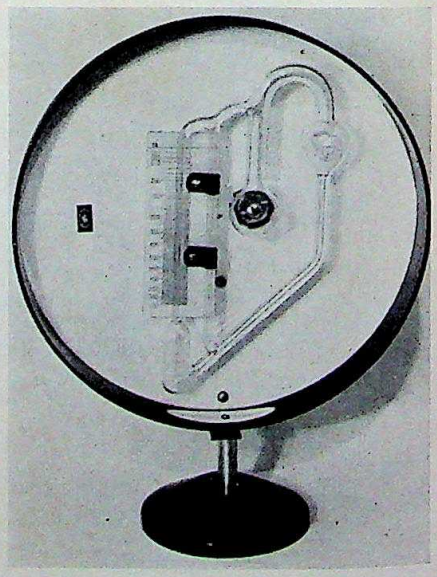

Figure 9. Manostat Tilting McLeod Gage.

(Continued on page A626)

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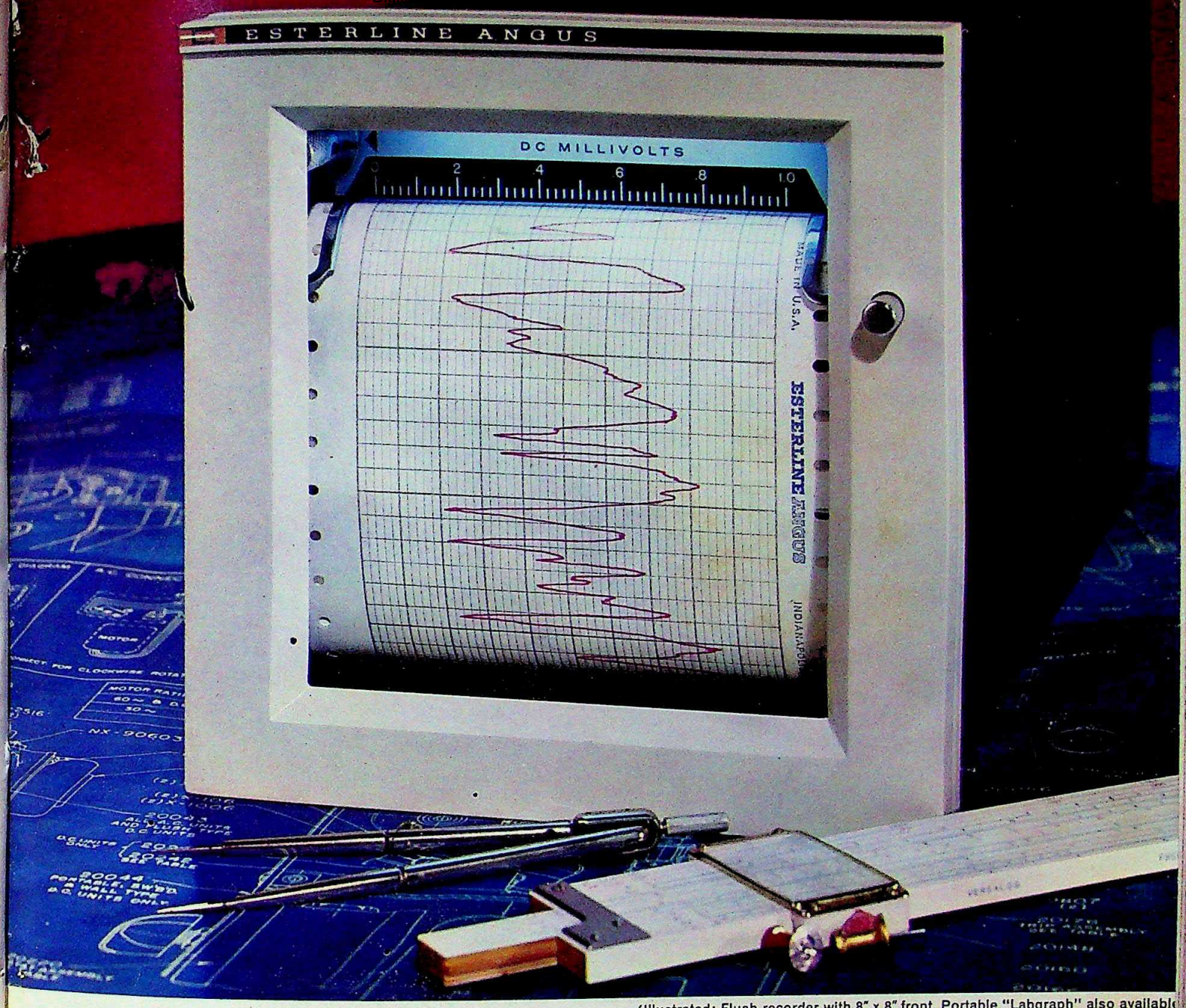

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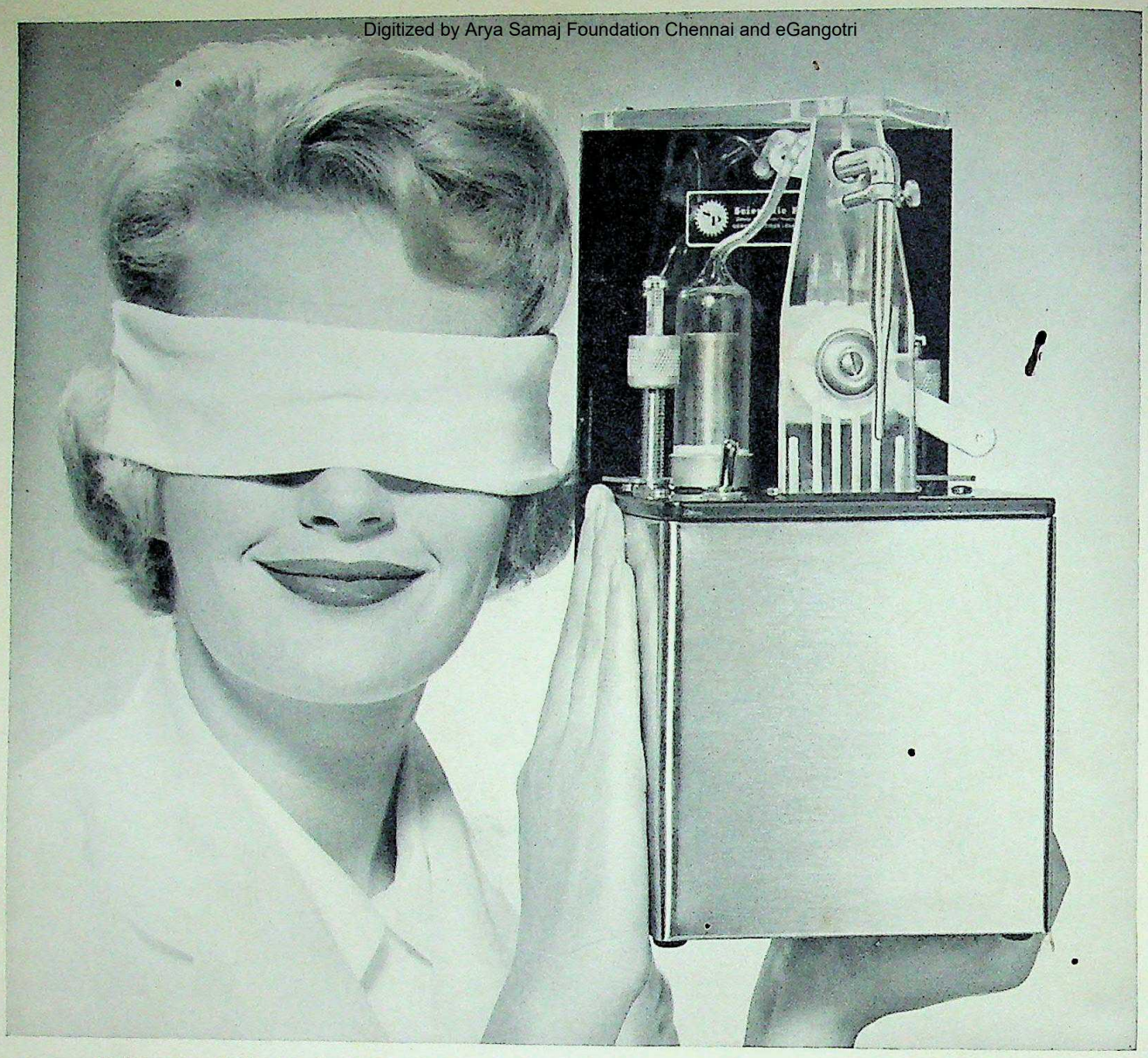

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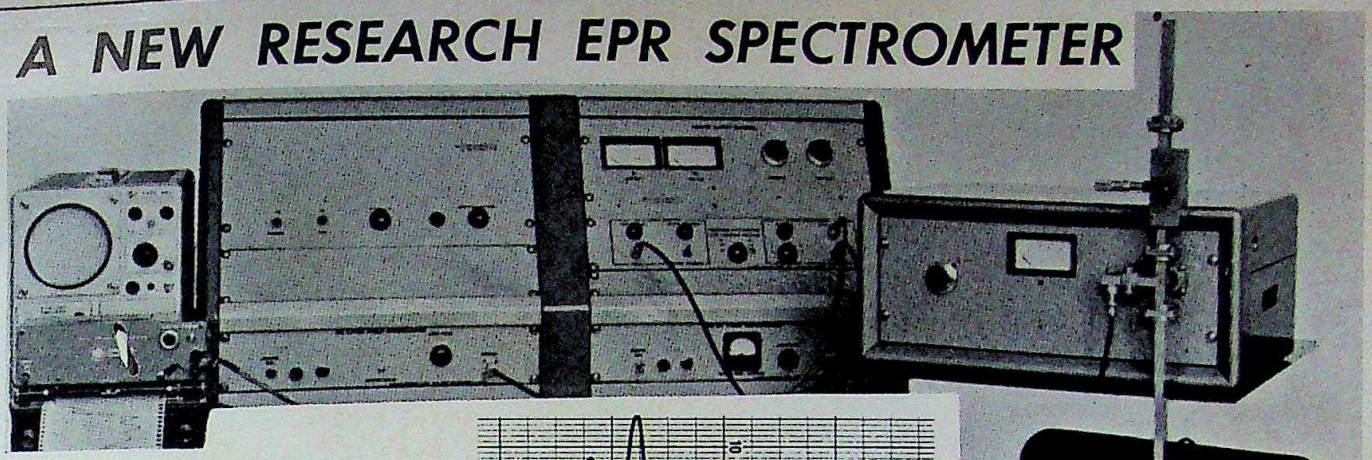

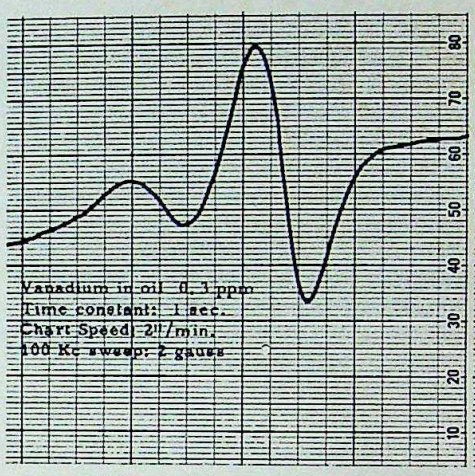

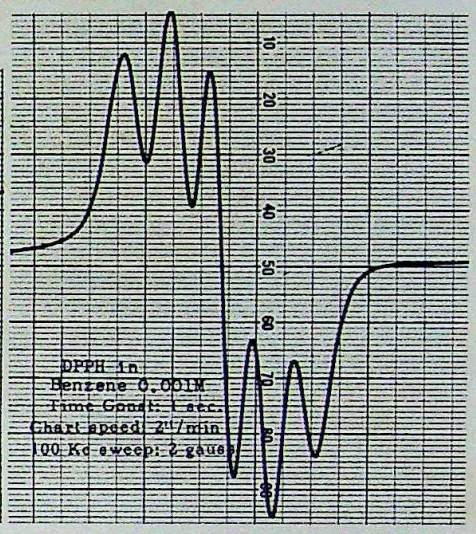

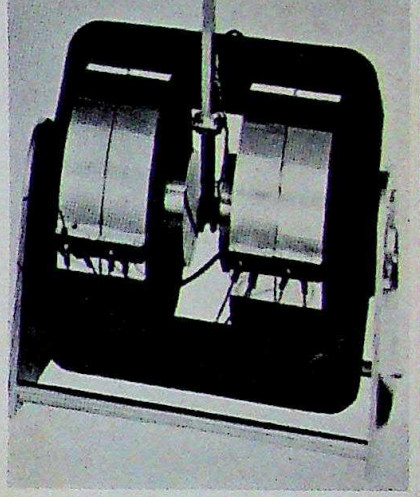

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Qualitative analysis of the vanadium resonance was accomplished by checking the value of the magnetic field at resonance against the standard sample DPPH resonance curve taken as a index of resonance position. Quantitative analysis of the number of atoms participating in the resonance signal is determined by integrating the area under the resonance signal and comparing with the standard sample. An integrating recorder attachment is an optional feature of the Alpha AL-X10 microwave Spectrometer.

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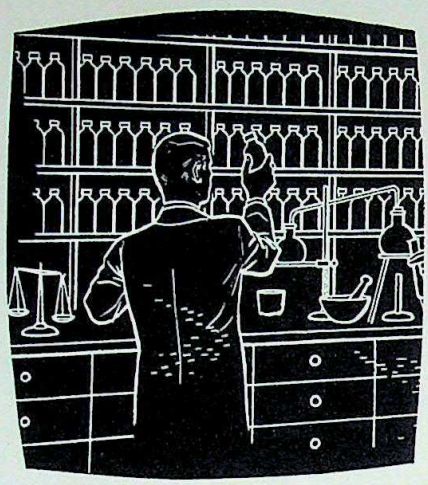

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Figure 10. Stokes Tilting McLeod Gage.

Since the pressure-range covered by a McLeod gage is determined by the relative sizes of the bulb and capillary, a dual-range gage can be made by providing either two bulbs of different sizes with a single closed-end capillary or a single

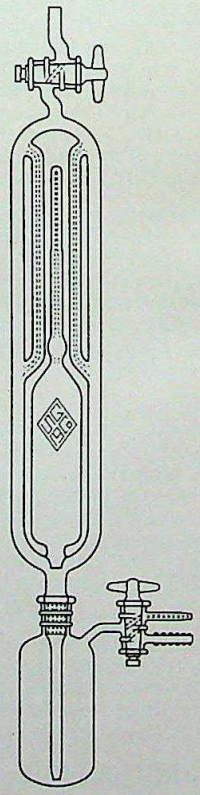

Figure 11. SGA Double Range McLeod Gage.

(*Continued on page A630*)

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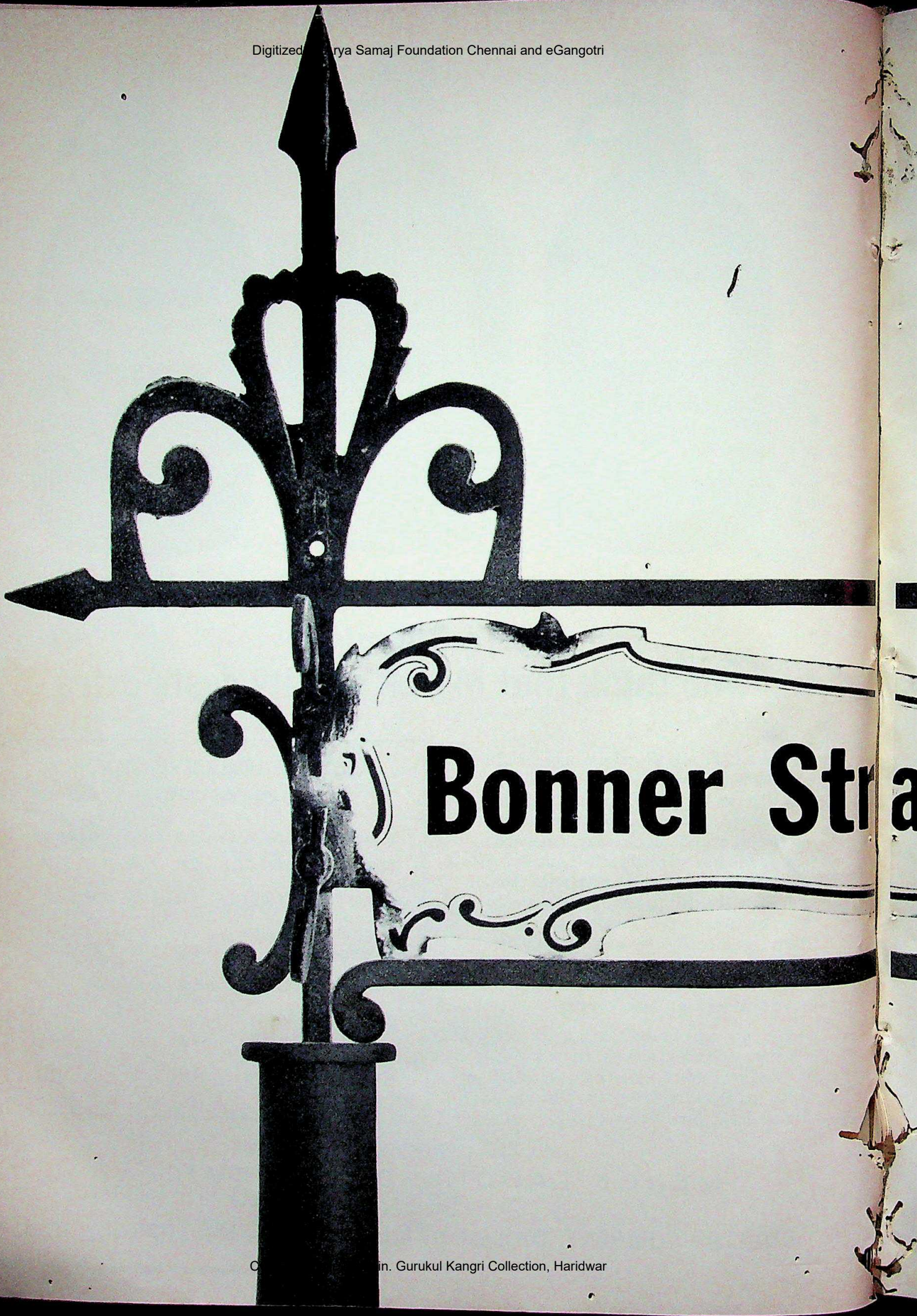

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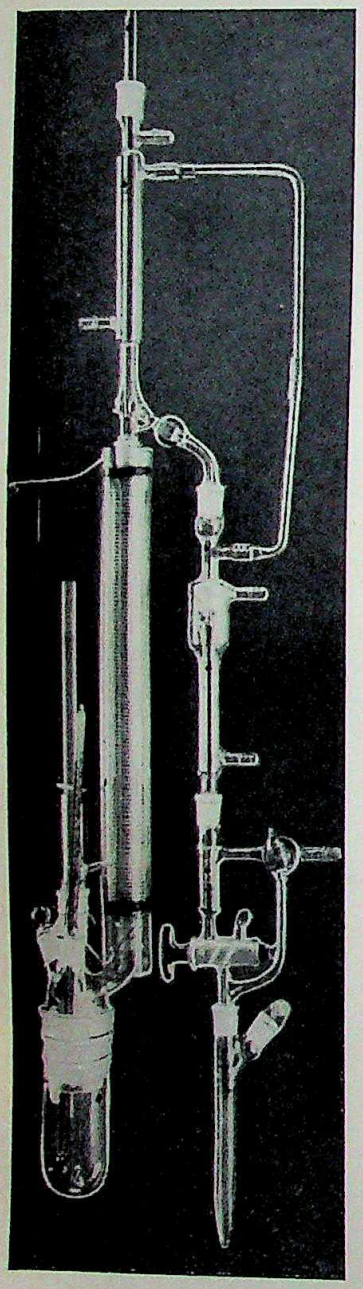

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bulb with two closed-end capillaries of different sizes. The latter type is shown in Figure 11, where the closed-end capillary (center) consists of two consecutive tubes of different bore. As a result, two bypass-capillaries are needed, one to match the bore of each segment of the closed-end capillary. In the Manostat Open End McLeod Gage (Figure 12),

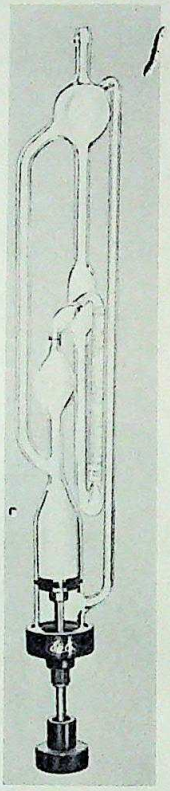

Figure 12. Manostat Open-End McLeod Gage.

two consecutive bulbs are used with a single measuring-capillary. A slight departure from the conventional design—the replacement of the closed-end capillary by a capillary U-tube—permits easy cleaning of the gage. Another convenient feature of this device is the simplicity with which the gas compression is accomplished—by the use of a piston with micrometer drive.

The RGI McLeod Gage (Fig. 13) also uses a micrometer-driven piston for compressing the gas, but seals the closed-end capillary by means of a plunger having three fixed positions which correspond to three final-volumes. By this means there is provided not only ease-of-cleaning but also three ranges. Absolute pressure is read directly on a linear scale which is engraved on the bypass-capillary, with the position of the plunger indicating the decimal multiplier.

Another McLeod gage which utilizes a piston for displacing the mercury is the Vacuum Gage 68 (Nester/Faust, Newark, Delaware. Available from Fisher Scientific Co.). It is shown in Figure 14.

Succeeding sections of this article will deal with mechanical, thermal, and ioniza-

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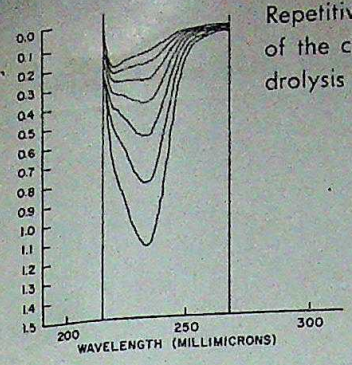
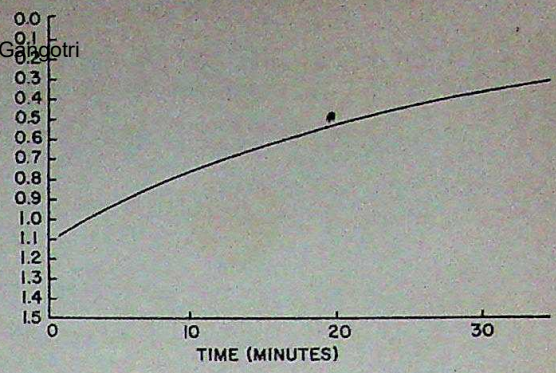


Repetitive scans at 10-minute intervals of the changes produced by the hydrolysis of glutethimide in KOH.



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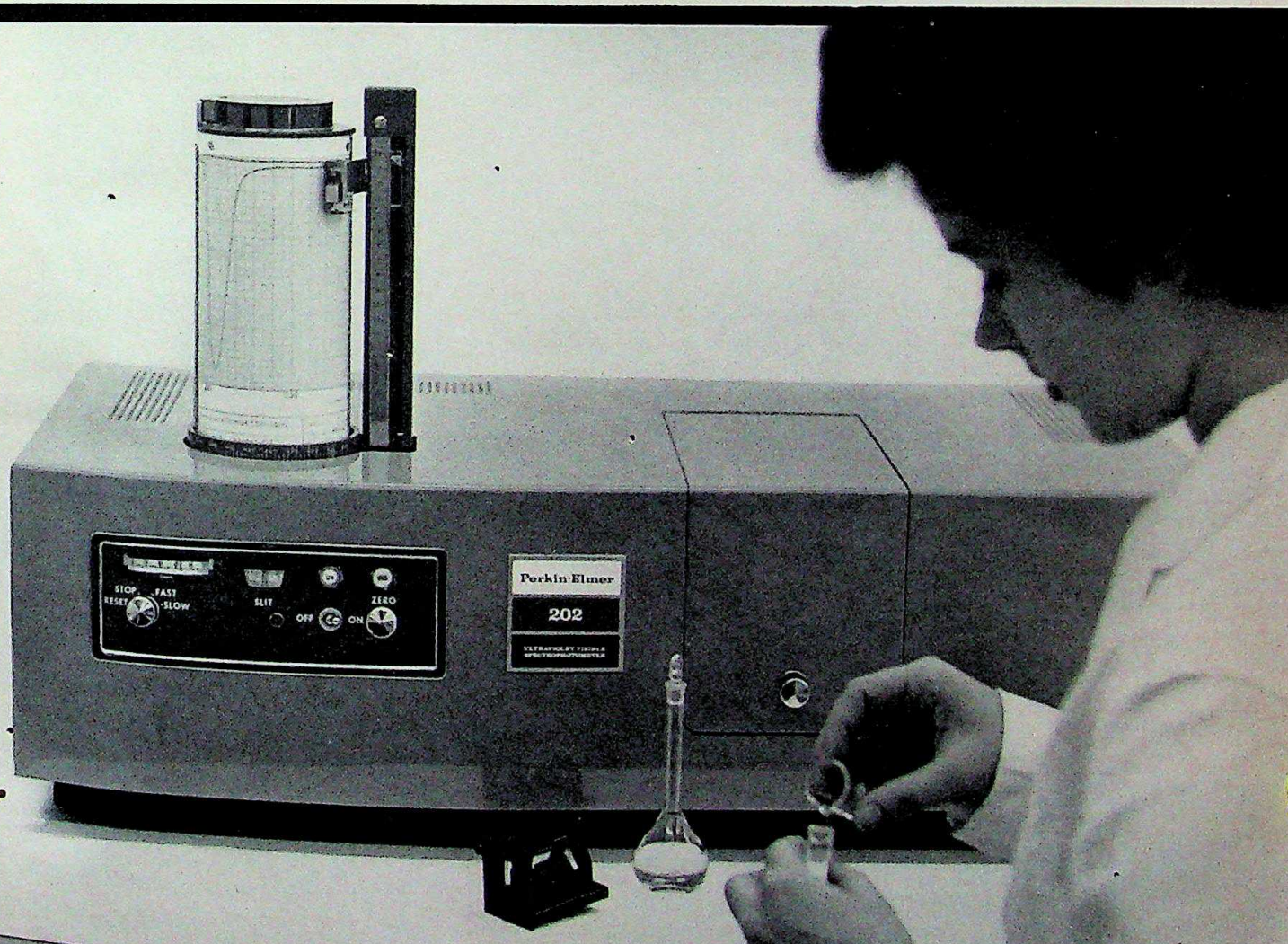

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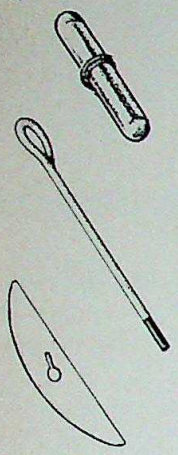

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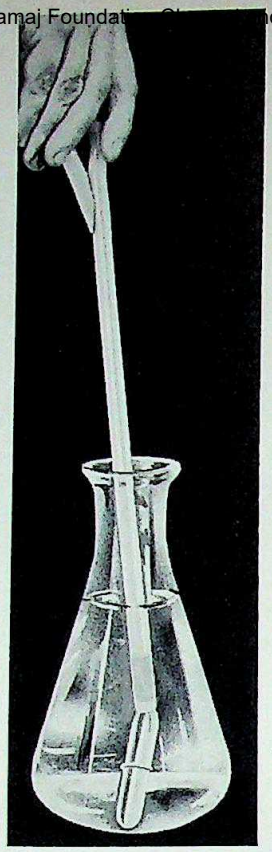

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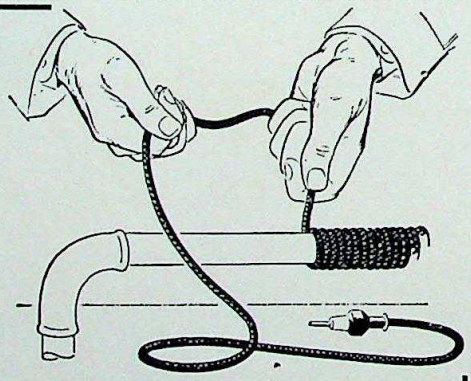

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tion gauges. A bibliography will be included with the last section.

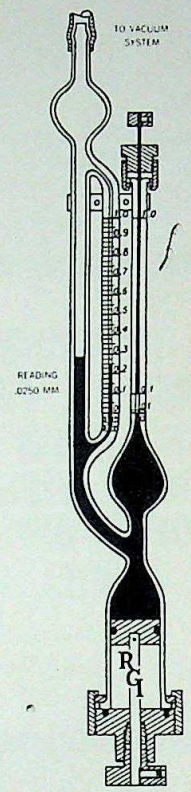

Figure 13. RGI Adjustable Closed-End McLeod Gage.

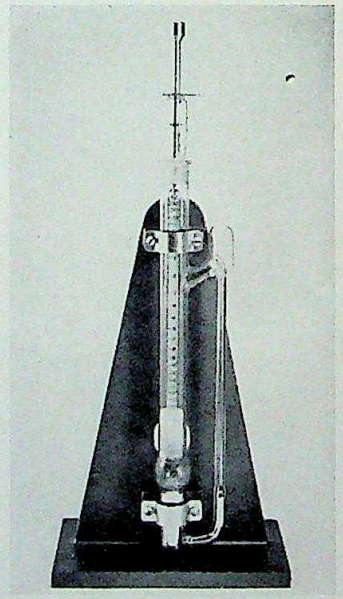

Figure 14. Nester/Faust Vacuum Gage 68

Literature Cited

(1) Dushman, S., "Scientific Foundations of Vacuum Technique," 2nd ed., John Wiley and Sons, Inc., New York, 1962, Chap. 5.

(2) Dubrovin, J., *Instruments*, 6, 194 (1933).

(3) Germann, F. E. and Gagos, K. A., *Ind. Eng. Chem., Anal. Ed.*, 15, 285 (1943).

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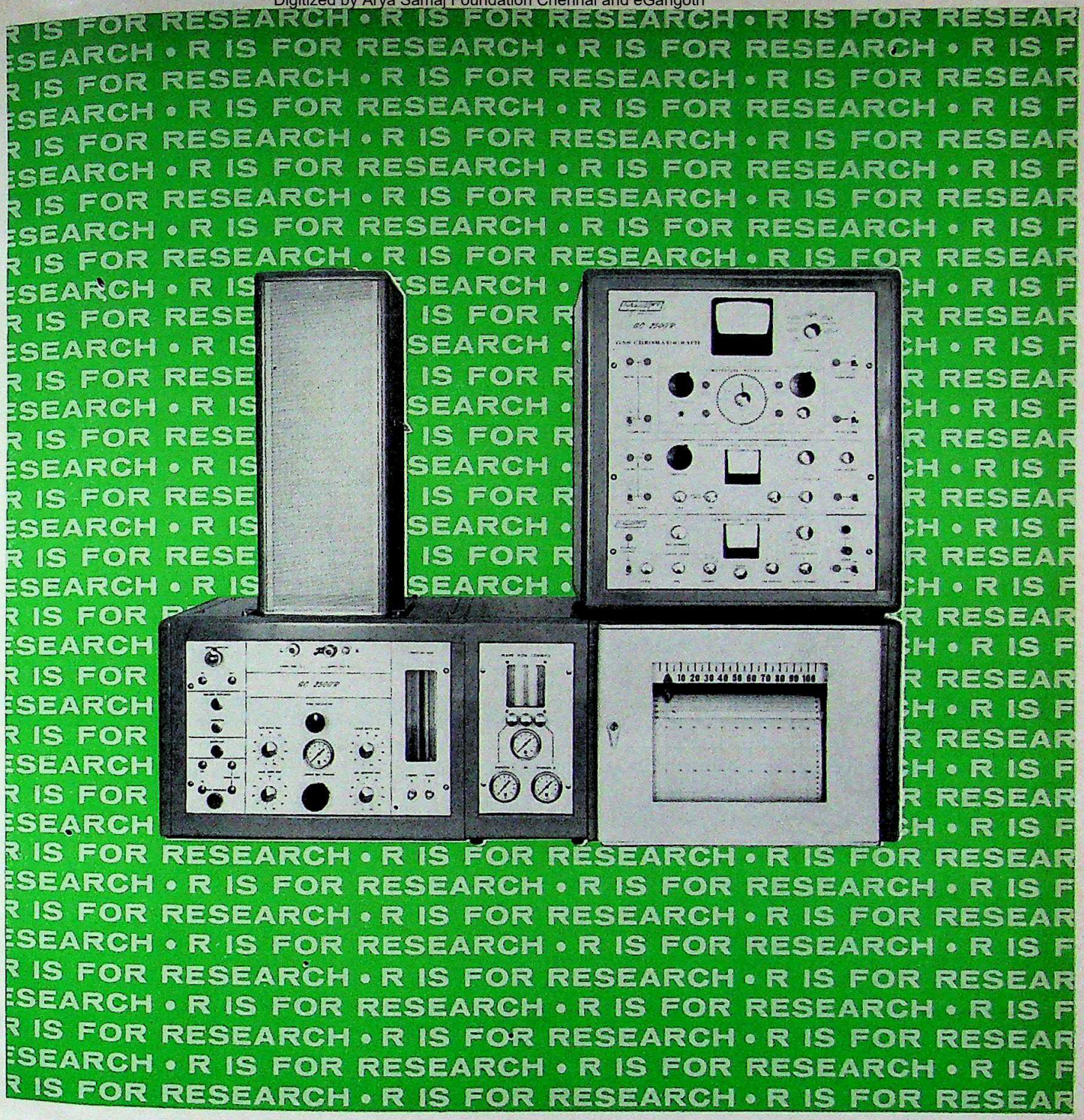

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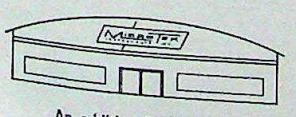

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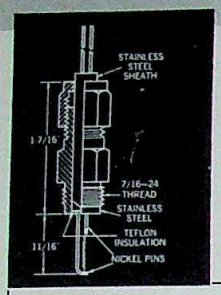

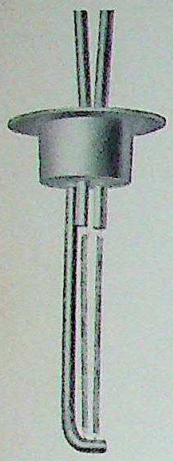

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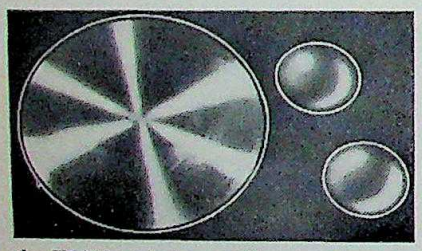

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For the remainder of the TOPS series the name of any person who worked in Princeton with the author on a demonstration will be indicated. To date this includes the following. **Philip Ashby**, Princeton, New Jersey. **Robert Barnard**, Montana State College, Bozeman, Montana. **Mrs. Lillias Brescia**, Manahawkin, New Jersey. **August J. Colo**, Irvington (New Jersey) High School. **Edwin H. Cooper**, Madison (New Jersey) High School. **Gerald G. Donaldson**, The Hun School of Princeton, New Jersey. **Raymond P. Garman**, Red Bank (New Jersey) High School. **LeRoy Hornbeck**, University of Washington, Seattle, Washington. **Miss Evangeline B. Klug**, Mahwah (New Jersey) High School. **Carl J. Mancuso**, East Side High School, Paterson, New Jersey. **Dr. Isjrin Noerdin**, Bandung Institute of Technology, Bandung, Indonesia. **Charles Owens**, N. R. Crozier Technical School, Dallas, Texas. **Alphonse Palermo**, Trenton Central (New Jersey) Central High School. **Crosby U. Rogers**, Joel Barlow High School, Redding, Connecticut. **Dr. Fred Rolf**, Northern Illinois University, DeKalb, Illinois. **Dean Soule**, The Lakeside School, Seattle, Washington. **John A. Stewart**, Princeton (New Jersey) High School. **Albert Surina**, Princeton, New Jersey. **Denver Ulery**, Ingraham High School, Seattle, Washington. **William O. White**, University of Western Ontario, London, Ontario, Canada. **Lucian J. Wnukowski**, Sayreville (New Jersey) War Memorial High School. **James A. Young**, Anthony Wayne High School, Wayne, New Jersey. If no name appears, the demonstration was carried out by the author and several persons. Experiments devised by undergraduates in the author's classes are also indicated, e.g., **R. Williams-'64**, Princeton, class of 1964.

4. WATER, ACIDS, BASES, SALTS

A. Water

1. Synthesis and Structure of Water

Recall Dem. 3— electrolysis of water, and synthesis from $2H_2 + O_2$

Dem. 86—Formation of H_2O During Combustion

To show: Water is one product of the combustion of a candle.

Materials: Candle, 60 mm glass funnel, two 1-ft lengths of rubber tubing, culture tube, 2-hole stopper, 4 mm glass tubing 2 in. and 7 in. long, ice, box H-3, 14-in. double sticky tape, two clear glass or Plexiglas plates $3^1/_2 \times 2 \times {}^1/_8$ in.

Preparation: Connect the funnel via the rubber tubing to the 7-in. glass tubing and insert in the stopper. Attach the other rubber tubing to the 2-in. glass tubing and insert in the other hole. Using four $3^1/_2$-in. strips of double sticky tape, fasten two $3^1/_2 \times 2$-in. plates to the H-3 box (these double windows, with air space between, prevent subsequent fogging). Insert the culture tube in the box two-thirds full of ice-water, with a few chunks of ice floating.

Procedure: Place the lighted candle on top of the projector where the class can see it. Place box and culture tube on the stage and project. Wipe off any moisture from the double windows, so the culture tube can be clearly seen. Lower the funnel over the burning candle, and suck the combustion products through the culture tube.

Observations: Water forms as a mist on the culture tube, as one of the combustion products.

Note: Presence of CO_2 can also be demonstrated by putting dilute limewater in the box and sucking the combustion products through it. $CaCO_3$ precipitates at first; after three minutes sucking the $CaCO_3$ dissolves to form soluble $Ca(HCO_3)_2$.

Reference: WALTON, J. H., *J. Chem. Educ.*, **19**, 453 (1942).

2. PHYSICAL PROPERTIES OF WATER

Purification

Dem. 87—Purification by Distillation

To show: Purification of water by distillation of $KMnO_4$-aq.

Materials: $KMnO_4$, cell H-3, one 4-in. culture tube, one 6-in. culture tube, a stopper with a 6 mm delivery tube (arms 5 and 16 cms long respectively) leading from the still to the collector, one-holed stopper, chunks of ice.

Procedure: Fill the 4-in. culture tube one-quarter full of tap-water colored a deep, transparent, pink with $KMnO_4$. Adjust this tube above burner in H-3 and insert delivery tube leading it into the 6-in. culture tube immersed in the box filled with water containing chunks of floating ice. Project. Heat.

Observations: A distillate of colorless, pure water collected in the receiver.

Note: Cell H-1 can also be used. Use a 3-in. culture tube for the still, another the same size for the collector, immersing the latter in the box of ice and water. Fill the still $^1/_4$ full of water and add one drop of $KMnO_4$-aq. to tint it. Clear water will distill over. (Rolf)

Dem. 88—Distillation in a Cryophorus

Materials: Cryophorus, shown in special device, SD-18. Dimensions are critical. After adding the colored solution, evacuate and seal. The water is colored with food coloring ($KMnO_4$ decomposes in sunlight and should not be used). Place hot water around the solution, cold water around the empty limb. In a few minutes clear water distills over. (Soule)

References: BAKER, P., *J. Chem. Educ.*, **27**, 617 (1950); BAKER, R. A., **25**, 259 (1948).

Dem. 89—Clarification by Adsorption

To show: Removal of mud or dye from water by adsorption on aluminum hydroxide.

Materials: Muddy water, Congo Red solution, conc. NH_4OH, $AlCl_3$-aq., cell C-2 and stirrer, or H-3.

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Procedure: Quarter-fill cells of C-2 with water. Project. Add 10 ml. 1M $AlCl_3$-aq. to each. Then add slowly, with stirring, 10 ml of conc. NH_4OH until $Al(OH)_3$ precipitates. Finally add 3 drops of Congo Red solution to one and muddy water to the other cell. Stir. Let settle.

Observations: $Al(OH)_3$ forms a gelatinous precipitate which settles slowly (1 hr) carrying dye or mud with it. (Owens)

Notes: The trick is to get the aluminum hydroxide to settle quickly and properly. Here are alternative methods. *Method 2:* Half-fill each cell with water. Add a few drops of muddy water; stir; add 2 droppersfull conc. NH_4OH; stir; add 3 droppersfull $AlCl_3$-aq.; stir. Later add more $AlCl_3$-aq. to show additional dirt is carried down (Rolf) *Method 3 (a).* Add 5 drops of muddy water and 10 drops of 6 N NH_4OH; shake; add 2 drops saturated $Al_2(SO_4)_3$-aq. Shake well.

Dem. 90—Flocculation

To show: Clarification of water by flocculation.
Materials: Sepran flocculating agent, aluminon, $Al_2(SO_4)_3$-aq. conc. NH_4OH, C-2, 100 ml beaker, stirrer.

Procedure: To the beaker half-filled with water add 1 ml $Al_2(SO_4)_3$-aq., then NH_4OH to light precipitate, then 3 ml of aluminon to color the precipitate. Pour into the two cells of C-2. Project. Now add 3 ml of Sepran flocculating agent to one, and stir. Let settle.

Observation: The flocculating agent causes rapid settling. (Williams '64)

Reference: Dutton, F. B., *J. Chem. Educ.* **34**, A347 (1957).

Dem. 91—Ion Exchange Water-Softeners

To show: Softening of water by passage through ion exchange resins.
Materials: Bogen's indicator, ion exchange resin (e.g. zeolite), Cell C-2, gas collector tube, glass wool. Hard water; if not available, add $CaSO_4$-aq. to soft water.

Procedure: Fill gas collection tube only half-full (to allow for expansion of resin when wet) of zeolite ion exchange resin. (*a*) Through the resin in the tube inverted in one of the chambers, pour half a cell-ful of hard water. Pour an equal amount of hard water directly into the other cell. Remove the gas holder with resin in it. Now add 5 drops (or more, by test) of soap solution to each cell. Stir. (*b*) Repeat, but this time add a drop of Bogen's indicator to each.

Observations: (*a*) The water which has been softened (Ca-salts removed) by passage through the ion exchange forms suds; the hard water does not. (*b*) The soft water is dark green with Bogen's indicator; the hard water forms light greenish yellow. (Owens)

Reference: *J. Chem. Educ.*, Editorial, **33**, A299 (1956).

Dem. 92—Testing Tapwater for Alkalinity

To show: The alkalinity of tap water.
Materials: Cell C-2; stirrer. Indicator A: 0.02 g methyl red + 0.1 g bromo cresol green in 100 ml 95% ethanol. Indicator B: 0.125 g methyl red + 0.0825 methylene blue in 100 ml 95% ethanol.

Procedure: (*a*) Fill cells two-thirds full of tap water. Add a few drops of Indicator A to each. Stir. (*b*) Repeat with Indicator B.

Observations: (*a*) Indicator A turns blue in alkaline, pink in acid.[1] (*b*) Indicator B turns green in alkaline, violet in acid.[2]

References: (*1*) Cooper, S. S., *Ind. Eng. Chem., Anal. Ed.*, **13**, 466 (1941). (*2*) Johnson, A. H. and Grun, J. R., *ibid.*, **2**, 2, 14, 130 (Z930). Also, Brooke, M., *J. Chem. Educ.*, **30**, 419 (1953).

Boiling Water

Dem. 93—Boiling Water at Reduced Pressure

To show: Boiling of water under reduced pressure.

Method 1.
Materials: Burner, 13 × 100 mm test tube or culture tube, glove or tongs.

Procedure: Fill the tube quarter-full of water. Bring to a boil then immediately (important) stopper tightly and invert in the projector.

Observation: As the steam condenses, a near-vacuum is produced. After a few moments the water in the inverted tube begins to boil.

Note: When boiling slows down, squirt a few drops of cold water from a syringe on the tube. Result: the water commences to boil again. (Palermo)

Method 2.
Materials: M° tube, rubber policeman, H-3 box, ice, vacuum source.

Procedure: Boil the water in M° tube half-full of water, stopper quickly with rubber policeman, then plunge the tube into an H-3 box of ice-water.

Observation: The near-vacuum causes the water to boil again.

Method 3.
Materials: Mp-O box, unglazed porcelain chips, vacuum source.

Procedure: Place four chips of unglazed porcelain in Mp-O box half-full of water. Project. Evacuate.

Observation: Bubbles soon begin to leave the chips and rise to the surface. (Ulery)

Reference: Baker, R. A., *J. Chem. Educ.*, **2**, 480 (1925).

Conductivity of Water

Dem 94—Heat Conductivity of Water

To show: Water is a poor conductor.

Materials: H-1, ice, copper wire or paper clip.

Procedure: Drop a small coil of wire to hold a half-inch chip of ice at the bottom of the culture tube in H-1. Half-fill culture tube with water. Project in H-1, with the flame striking the middle portion of the water above the coil. Boil several minutes.

Observation: Water is so poor a conductor of heat that ice, water, and steam exist simultaneously.

Note: This experiment can also be used to illustrate the three states of matter. (Ulery)

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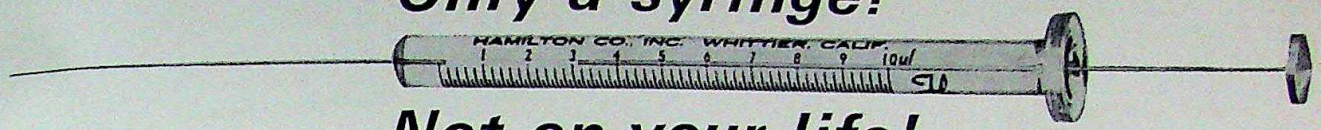

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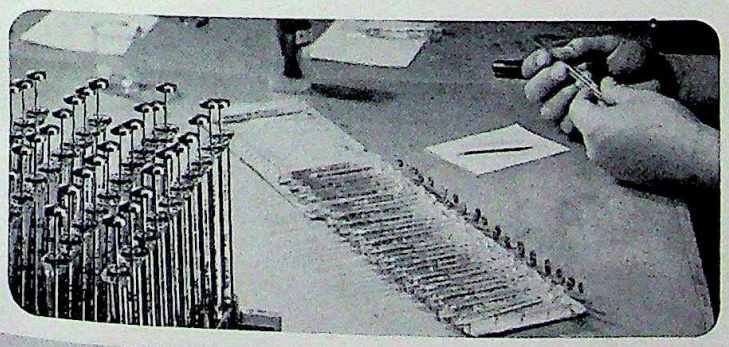

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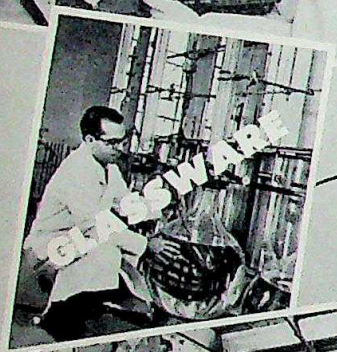

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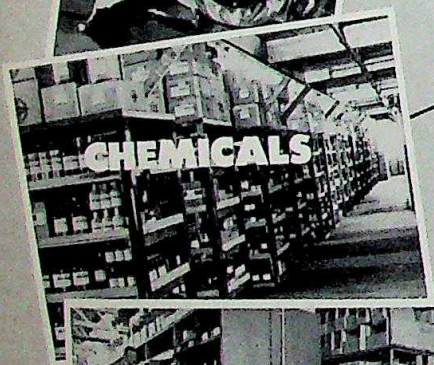

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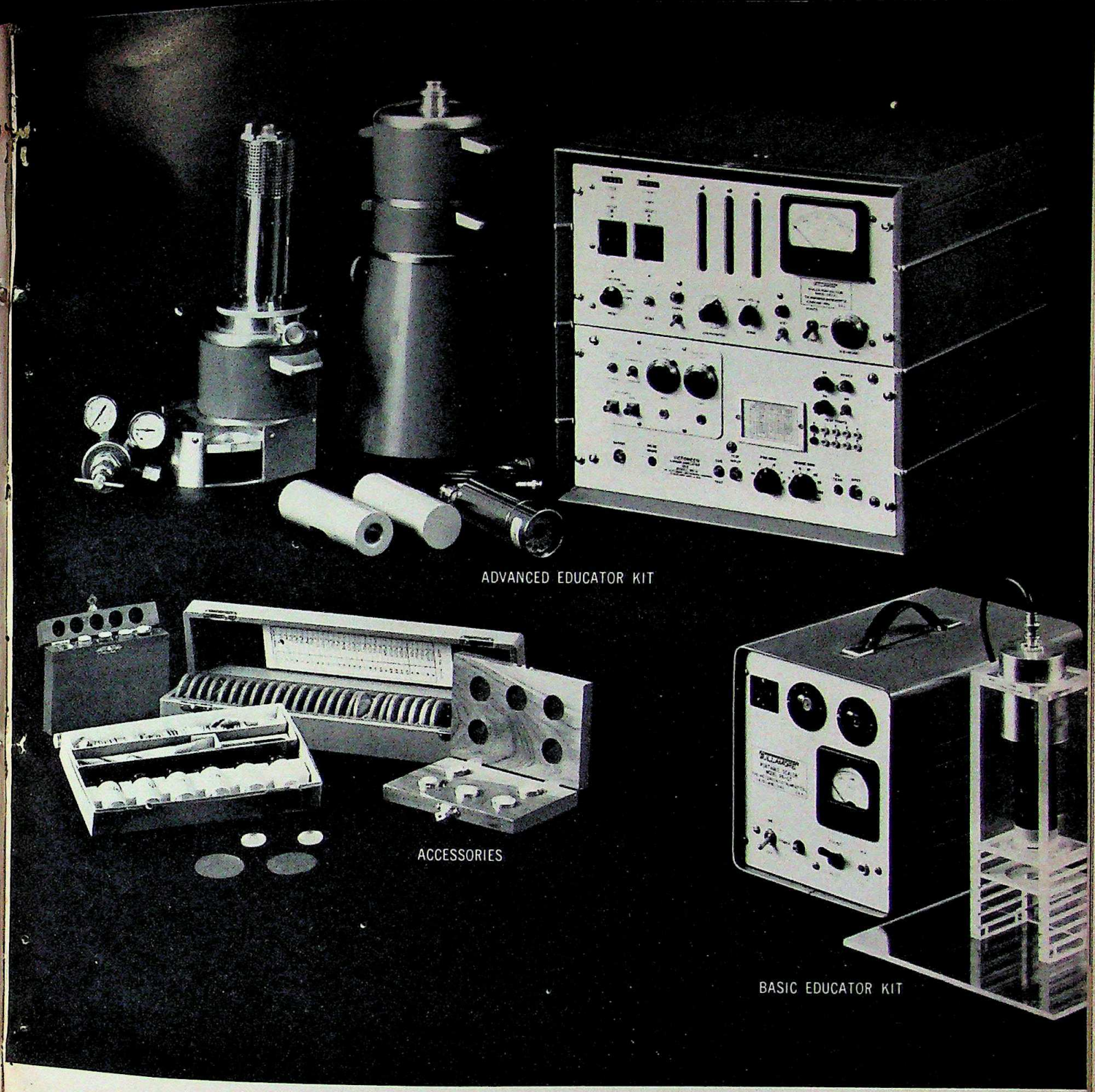

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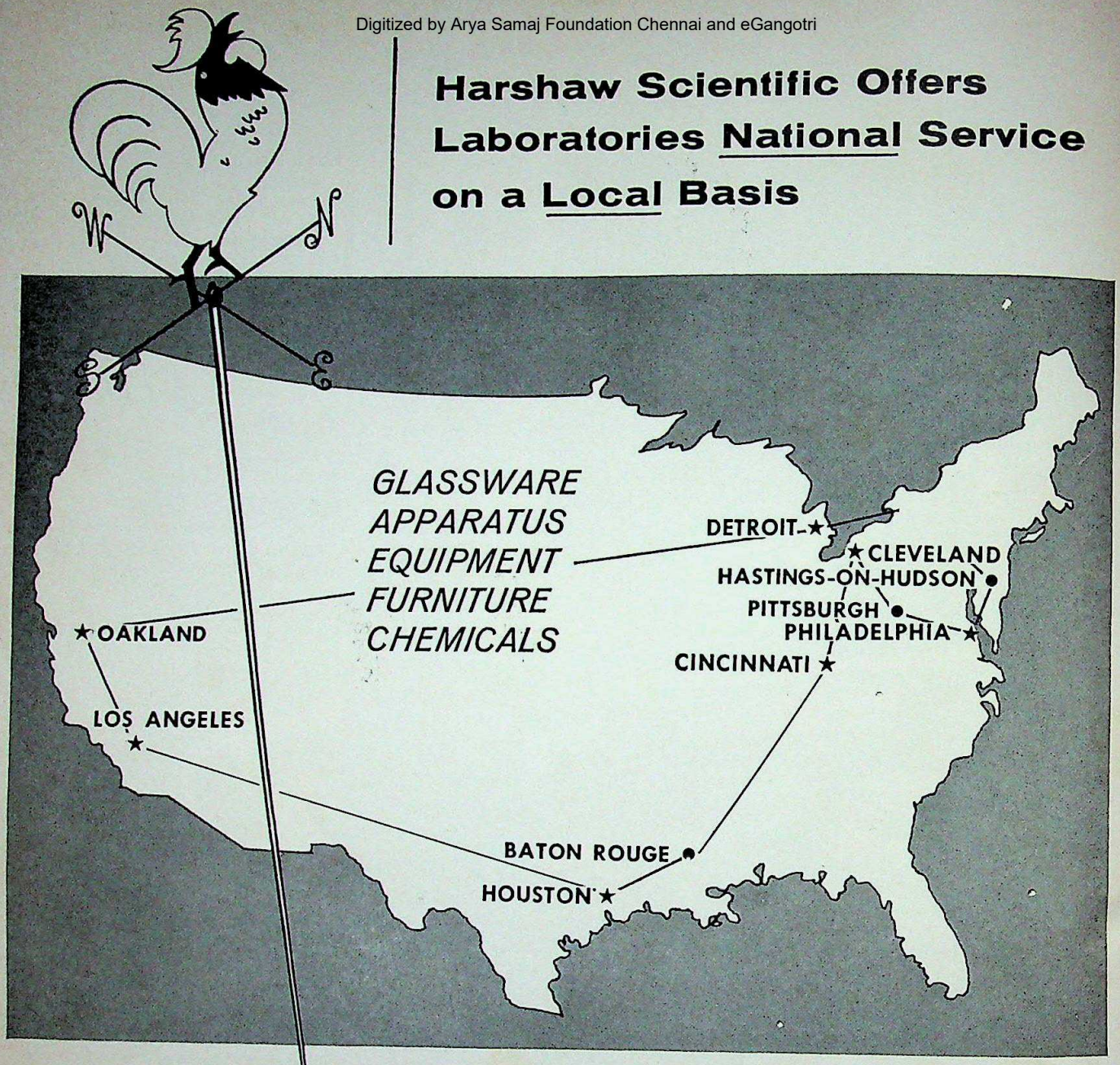

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When writing for additional information about new products or for new literature, your inquiry will receive prompt attention if you write on your firm or Institution letterhead and mention the Journal of Chemical Education and the date of the particular issue. Pamphlets, booklets and similar literature are gratis unless otherwise specified.

New Apparatus and Equipment

▶ A new type of power supply designed to operate Xenon, Xenon-Mercury, and Mercury high pressure short arc lamps at highest efficiency is now being manufactured by Schoeffel Instrument Co. Models for straight ac or ac/dc operation are available. The unit incorporates volt and ampere meters, adjustable current control, and high voltage starting supply with push-button control. A universal lamp housing with built-in blower cooler, UV transmitting optics, and spherical reflector is available for convenient mounting of high pressure arc lamps as as well as numerous discharge lamps.

A bulletin containing more details is available from Schoeffel Instrument Co., 355 Hillsdale Ave., Hillsdale, New Jersey.

▶ The Dri-Lab/Dri-Train designed to fill the need for precisely controlled atmospheres in research and production in widely divergent fields of modern technology including: studies with radioactive materials, reactive metals, propellant mixtures, lox cleaning, toxic compounds, and atmospheric pollution control is now available from D. L. Herring Corp., Van Nuys, California.

▶ Ohaus Scale Corp., 1048 Commerce Ave., Union, New Jersey, announces the availability of their complete line of Sto-A-Weigh weight sets in the new one-piece molded polypropylene case with integral "living hinge" and self-latching cover.

▶ Packard Instrument Co., Inc., Box 428, La Grange, Illinois, manufacturers of Tri-Carb Liquid Scintillation Spectrometers, has recently introduced two chromatogram scanning systems, Analog (Model 7201) and Digital (Model 7202), designed for automatic and precise localization of radioactivity on paper strip chromatograms. An optional attachment permits scanning of thin layer chromatogram plates.

▶ Trace elements can now be analyzed, in minutes, at concentrations down to 0.0001 ppm by a new Atomic Absorption and Flame Spectrometer manufactured by the Jarrell-Ash Co. at Farwell St., Newtonville, Massachusetts.

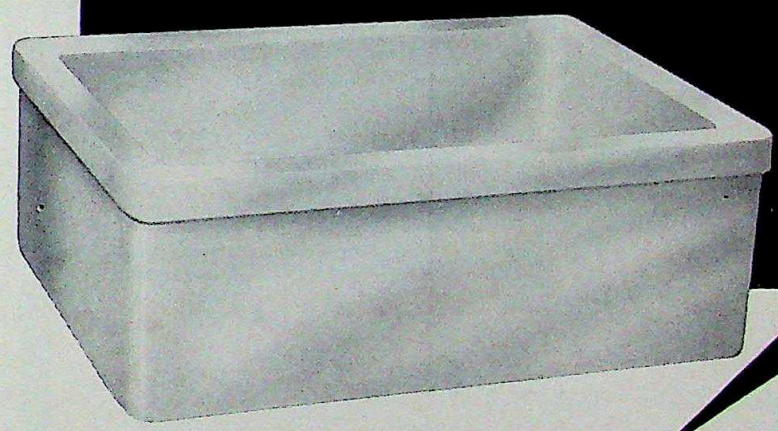
▶ Three new microwave power generators have been introduced by Raytheon Company's Commercial Apparatus and Systems Division. The new PGM-10 series delivers precisely controlled microwave energy for laboratory research projects such as the production of free radicals, excitation of electrodeless discharge lamps for spectroscopy, raman spectroscopy, and interferometry. Complete specifications are available from Edward T. Keating, Production Equipment Dept., Raytheon Co., Hooksett Plant, Manchester 26, New Hampshire.

▶ A new, Norelco Simultaneous X-ray Spectrometer, a fixed channel system that analyzes from one to six elements simultaneously, has been announced by Philips Electronic Instruments, 750 So. Fulton Ave., Mount Vernon, New York.

▶ Schuco Scientific, 250 W. 18th St., New York 11, N. Y., has been appointed a distributor of the Nonius X-ray diffraction equipment line. Included in the range of instruments available are 2 circle goniometers, microdensitometers, an integrating precession goniometer and camera, Guinier-deWolff cameras for powder diffraction, Von-Eller Photosommateur, general purpose camera, Rimsky-retigraphs, etc.

(*Continued on page A644*)

Ageless... Timeless... of Proven Durability



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Substitute materials may come and go, but solid chemical porcelain stands out as the one material with a record of proven performance against time and corrosion through years of usage. In many installations, sinks of chemical ceramic have been in service for 100 years and more — often outlasting the building itself! There is positive assurance of continuous dependable service in the years ahead when your plans include "U.S." Chemical Porcelain Sinks.

You get lasting beauty, too! The modern, smooth "surf green," soft "mist gray" and sparkling white finish is an integral part of the solid porcelain body. Can't peel or flake off, won't absorb stains or odors, never needs honing or scouring. Safely handles all corrosive chemicals and acids in normal laboratory use — no need to consult "chemical resistance" charts. One-piece seamless construction with rounded corners for ease of cleaning.

Wide range of standard types and sizes for prompt delivery. Check your Laboratory Furniture Dealer or write direct for Catalog L-10.

CHEMICAL CERAMICS DIVISION

U. S. STONEWARE

AKRON 9, OHIO

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Out of the EDITOR'S BASKET

▶ Four new plastic labware products—a slide box, a vial holder, disposable beakers, and disposable funnels—are being made by the Econo-Lab division of Maryland Plastics, Inc., 9 E. 37th St., New York, N. Y., the manufacturer of Econo-Cages for laboratory animal housing.

▶ A fully automatic instrument for faster moisture determinations has been introduced by Dynatronic Instruments Corp., 3070 W. Grand Ave., Chicago 22, Illinois. The built-in electronic calculator automatically registers results within 4 to 5 seconds after conclusion of the test. It can be used in the plant and laboratory and is so easy to operate that prior experience is not necessary.

▶ The availability of a new Kimax filter flask (27065) was announced recently by Owens-Illinois, Toledo 1, Ohio. This addition to the Kimble line of glass laboratory apparatus is made from Kimax (hard) glass and features a detachable plastic side-arm which is available in five sizes—from 250 to 4000 ml.

▶ A newly designed polyethylene aspirator bottle, with tubulation and bottle blow molded in one piece, is announced by the Nalge Co., Inc., 75 Panorama Creek Dr., Rochester 25, New York.

▶ A new accessory permits simple and elegant thermogravimetric analysis with the Cahn RG automatic electrobalance. The Cahn "Little Gem" TGA Kit provides unprecedented resolution and signal-to-noise ratio, exceptional accuracy in both temperature and mass, and high scanning speed, and preserves the unequalled sensitivity of the RG electrobalance, to finer than one microgram, even while heating in air. For details write Cahn Instrument Co., Paramount, California.

▶ A new cold-cathode type discharge gauge (Model DG-264) for the accurate and uniform measurement of high vacuum introduced by F. J. Stokes Corp., 5500 Tabor Rd., Philadelphia 20, Pennsylvania.

▶ Magnion's iron core Cryoflux superconducting magnets provide extremely high magnetic fields at moderate cost. Specially designed iron pole pieces and end plates greatly increase the magnetic field which would be achieved by the superconducting solenoids alone. For further information, contact A. J. Donius, Magnion, Inc., 195 Albany St., Cambridge 39, Massachusetts.

▶ A new precision electromagnet providing field of high homogeneity has been developed by Alpha Scientific Laboratories, Inc. The construction is of very soft magnetic iron throughout, with considerable attention to grinding and polishing details to maintain a high degree of homogeneity and parallelism. For additional information contact: J. W. Bodnar, P.O. Box 333, Berkeley 1, California.

▶ Buchler Instruments, Inc., 1327 16th St., Ft. Lee, New Jersey, announces the introduction of a photoelectric volumetric dispensing head for fraction collectors. The outstanding feature of the Buchler volumetric head is its consistent accuracy with both organic and aqueous solutions. The errors encountered with siphon collection method are entirely eliminated. Preset volumes from 1 to 20 ml will be accurately measured.

New Literature

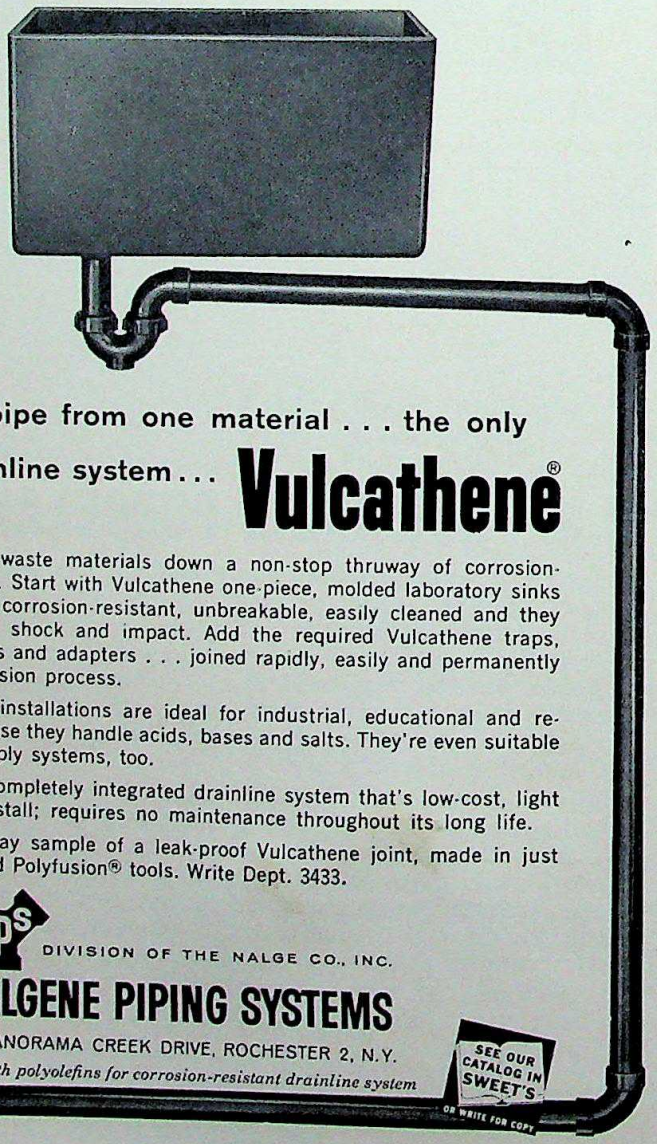
● Melting point determination in one minute with the Kofler Hot Bench is described in a leaflet available on request from William J. Hacker & Co., Inc., Box 646, West Caldwell, New Jersey.

● Details of the Model 202 Ultraviolet-Visible spectrophotometer, designed for automatic analyses of high accuracy and repeatability, are provided in a new brochure from Perkin-Elmer Corp., Main Ave., Norwalk, Connecticut.

● *The Handling and Storage of Liquid Nitrogen*, a nine page bulletin prepared by the Office of the Director of Defense Research & Engineering, is available gratis from Cryogenerators, Division of North American Philips Co., Inc., Mendon and Angell Rds., Ashton, Rhode Island.

● *Bulletin C-1* describing the Sargent micro, semi-micro, and 15 ml centrifuges has just been released by E. H. Sargent & Co., Dept. C-1, 4647 W. Foster Ave., Chicago 30, Illinois.

NON-STOP THRUWAY FOR CORROSIVE WASTES...



Sinks, traps, pipe from one material . . . the only complete drainline system . . . **Vulcathene®**

Send your corrosive waste materials down a non-stop thruway of corrosion-resistant polyethylene. Start with Vulcathene one-piece, molded laboratory sinks . . . they're durable, corrosion-resistant, unbreakable, easily cleaned and they withstand mechanical shock and impact. Add the required Vulcathene traps, pipe, fittings, couplers and adapters . . . joined rapidly, easily and permanently by a patented heat fusion process.

Vulcathene drainline installations are ideal for industrial, educational and research facilities because they handle acids, bases and salts. They're even suitable for potable water supply systems, too.

Vulcathene offers a completely integrated drainline system that's low-cost, light in weight, easy to install; requires no maintenance throughout its long life.

Send for your cut-away sample of a leak-proof Vulcathene joint, made in just seconds with patented Polyfusion® tools. Write Dept. 3433.

NPS DIVISION OF THE NALGE CO., INC.

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75 PANORAMA CREEK DRIVE, ROCHESTER 2, N.Y.

First with polyolefins for corrosion-resistant drainline system

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Out of the EDITOR'S BASKET

● A new line of cryogenic apparatus, ranging from ready-to-use cryostats to dewars and handling equipment has been introduced by Delmar Scientific Laboratories, Inc., 42 Madison St., Maywood, Illinois, in its new cryogenic apparatus catalogue.

● TLC Densitometer, a new addition to the Photovolt Densitometer line, is a specialized instrument for direct scanning of thin layer chromatographic plates through the glass. *Bulletin No. 367* is available on request from Photovolt Corp., 1115 Broadway, New York 10, N. Y.

● Gerald K. Heller Co., P.O. Box 4426, Las Vegas, Nevada, announces a new addition to their line of motor controllers. The new S10 Motor Controller is a solid state silicon device, designed to operate shunt wound Heller 2T60 plain and gear motors on 115 volts ac, single phase 50–60 cycles.

● A new catalogue describing 20 science-education kits, coverings, wave motion, charge particles, nuclear magnetic resonance, magnetism, rotational motion, and semiconductor electronics can be obtained from The Ealing Corp., 2224 Massachusetts Ave., Cambridge 40, Massachusetts.

● *Bulletin L-100*, a four-page color brochure, describes operations and detailed specifications for the new line of Welsbach laboratory ozonators and ozone meters. For a copy write The Welsbach Corp., Oxone Processes Division, Westmoreland and Stokely Streets, Philadelphia 29, Pennsylvania.

● A complete listing of materials for use in conjunction with the Chemical Education Material Study (CHEM Study) Laboratory Manual, "Chemistry—An Experimental Science," has been published by the Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Illinois. Write the Educational Service Bureau for a copy.

● *Silicology*, a new quarterly publication on silicones and silicone chemistry, has been introduced by Union Carbide Corp., Silicones Division. Its purpose will be to discuss silicones in each of their various forms and their broad range of applications. Printed in two colors and illustrated, it is devoted almost entirely to previously unpublished material on silicones. The new quarterly is available from Union Carbide Corp., Silicones Division, Dept. 0334, 224 Market St., Newark 2, New Jersey.

● A new 6-page folder, containing complete technical information on the new Norelco AMR/3 electron probe microanalyzer, is available on request from Philips Electronic Instruments, 750 So. Fulton Ave., Mount Vernon, New York.

(*Continued on page A646*)

The Welch
CATHETOMETER

Significant recent engineering improvements in this instrument insure better performance than ever and more years of satisfactory service.

This cathetometer is designed for precise measurement of vertical distances through a range of 100 cm. It is particularly useful where the object to be observed is not conveniently accessible, or may easily be disturbed by physical contact, or must be located in a position too hazardous to permit the observer to be in close proximity.

It is also commonly employed for qualitative telescopic viewing within the laboratory because of its versatile positioning adjustments and over-all stability.

Vertical Range	100 cm
Smallest Reading by Vernier	0.05 mm
Telescope	
Working Distance	45 cm to Infinity
Angular Magnification	12X at 45 cm 8X at Infinity
Reticle	90-degree crosshairs
Level Sensitivity	50 Seconds

No. 0068A—Each $257.50

Write for illustrated circular describing the many excellent features of this instrument

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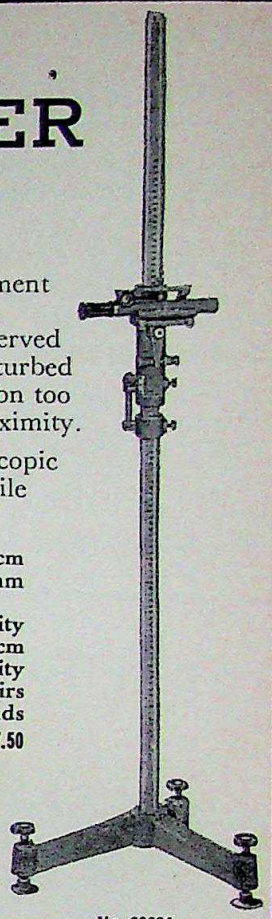
ESTABLISHED 1880
1515 Sedgwick St., Dept. D-1, CHICAGO 10, ILL., U.S.A.
Manufacturers of Scientific Instruments and Laboratory Apparatus



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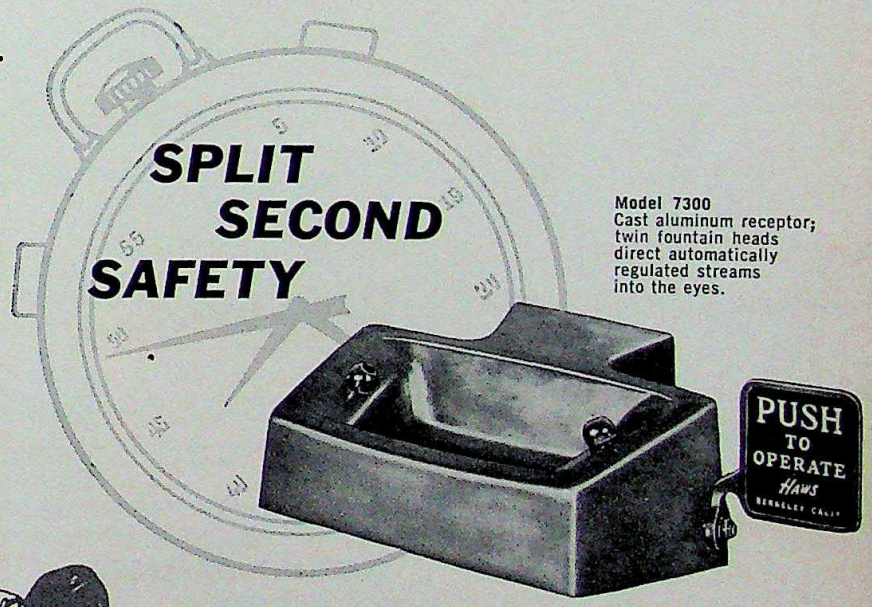

EMERGENCY EYE-WASH

Sensitive eye tissue can be destroyed in moments. Contamination from industrial caustics and chemicals requires instant first aid . . . and a HAWS Emergency Eye-Wash Fountain can mean the difference between temporary irritation and permanent injury! Write for your free HAWS catalog.

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a product of HAWS DRINKING FAUCET COMPANY 1443 Fourth St., Berkeley 10, Calif.

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Out of the EDITOR'S BASKET

● A new grating infrared spectrophotometer which covers the broad range of 4000 to 400 cm^{-1}, 2.5 to 25 microns, has been announced by the Instrument Division, Perkin-Elmer Corp., Norwalk, Connecticut. The low cost bench analysis instrument offers high resolution and flexibility in a compact, rugged package.

● A brochure describing Microfiche "a new medium for the dissemination and storage of information" is available from Micro Photo Division of Bell & Howell Co., 1700 Shaw Ave., Cleveland 12, Ohio.

Microfiche is defined in the brochure as "a transparent sheet of film 6 in. times 4 $^1/_8$ in. in size. It has all the advantages of film plus the flexibility of the index card concept. Each Microfiche contains multiple micro images of pages arranged in rows."

● A line of specific ion electrodes is described in an 8-page illustrated *Bulletin No. 7017* just released by the Technical Information Dept., Scientific and Process Instruments Division of Beckman Instruments, Inc., 2500 Harbor Boulevard, Fullerton, California.

● The Hamilton Co., Inc., P.O. Box 307, Whittier, California offers its 1963 Hamilton Catalogue on *Precision Syringes and Related Equipment.*

● Humidity—how to define it, sense it, and control it—is the subject of a new 12-page illustrated brochure published by Honeywell's special sensor products group, 2727 Fourth Ave., South, Minneapolis 8, Minnesota.

● Penn-Chem Corp., 232 N. Marshall St., Lancaster, Pennsylvania, is making available a complete personalized kit (suitable for filing) containing all the current literature, information, and prices on over 90 exclusive Penn-Chem products for the chemical and allied professions.

● Copies of the Engelhard Industries *Technical Bulletin*, Volume III, No. 4, may be obtained from the Technical Service Dept., Engelhard Industries, Inc., 75 Austin St., Newark 14, New Jersey. It features "The Testing of Catalysts for Ethylene Oxide Synthesis," "Iridium Alloy Wires for High Temperature Springs," Tungsten 3 Rhenium versus Tungsten 25 Rhenium—A New High Temperature Thermocouple," and "Stereochemistry of Hydrogenation of Cresols and Methylcyclohexanones with Rhodium Ruthenium, and Platinum Catalysts."

● *Masterpieces of Precision* describes each step in the manufacture of diffraction gratings, including: selection of quality glass, vacuum coating, and the almost unbelievable precision demanded of the special ruling engines. Included with the booklet is a comprehensive listing of hundreds of gratings now available from Bausch & Lomb. Copies may be obtained by writing to Bausch & Lomb Inc., Rochester 2, New York, specifying *Catalog #D-2030.*

● A new *Bulletin No. 7018* from the Scientific and Process Instruments Division of Beckman Instruments, Inc., 2500 Harbor Boulevard, Fullerton, California describes the Division's line of ultraviolet source lamps and a new dual source unit for Beckman spectrophotometers.

● Vanguard Instrument Co., P.O. Box 244, La Grange, Illinois offers a four-page folder describing its new compact Model 1-056-A UV analyzer.

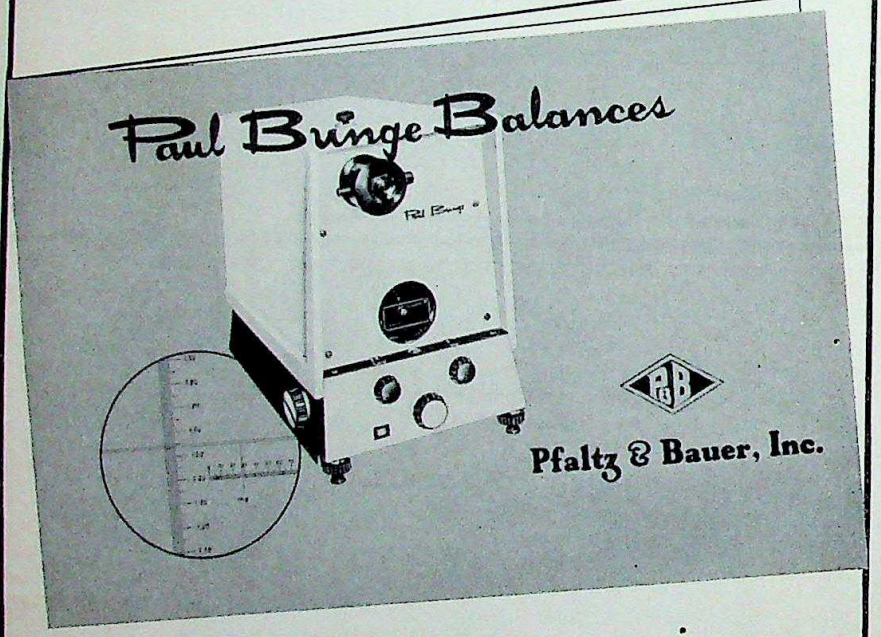
● Single copies of *Agricultural Chemicals, What They Are/How They Are Used* are available from the Manufacturing Chemists' Association, Inc., 1825 Connecticut Ave., N. W., Washington 9, D. C. The 64-page booklet emphasizes the problems which arise through unwise use of these chemicals and the contributions and machinery established by industry and government to insure their safety and effectiveness. The booklet was published in cooperation with a panel of recognized scientific authorities which reviewed the material and assisted greatly in its publication.

● The new Mervyn modular Mark IV square wave polarographic analyzer is described in an illustrated *Bulletin GBla* offered by Gulton Industries, Inc., 212 Durham Ave., Metuchen, New Jersey.

Designated Mark IV, the new instrument is an advanced version of the an-

(*Continued on page A648*)

Specify



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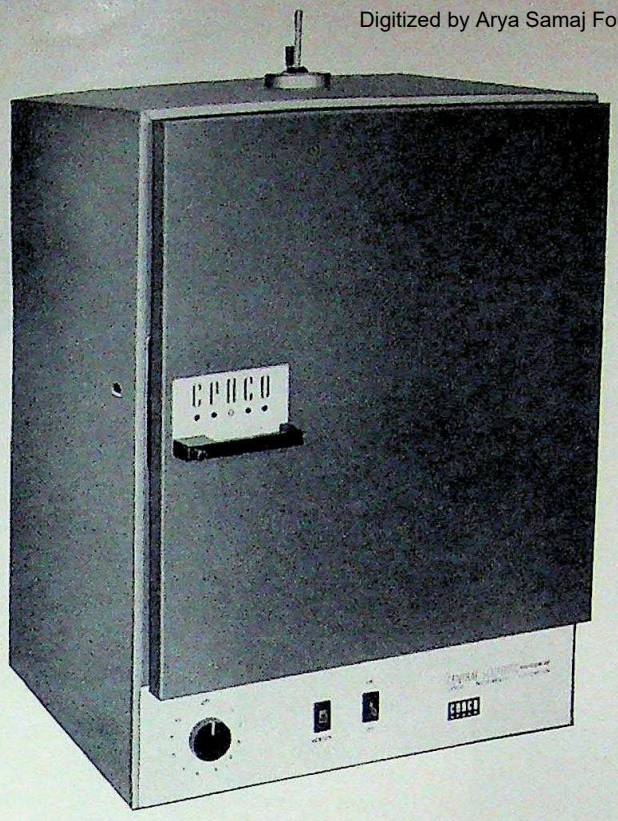
THE NEW SERIES 16 CENCO OVENS



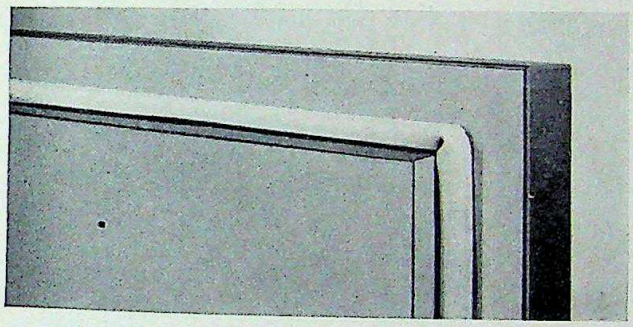
Smartly designed cabinets blend with modern lab interiors.

Announcing 16 new Cenco double wall ovens from which you can choose the interior capacity and lining, line voltage and mode of circulation that exactly meets your needs—whether it be in the lab or on the production line. Every model offers these Cenco extras:

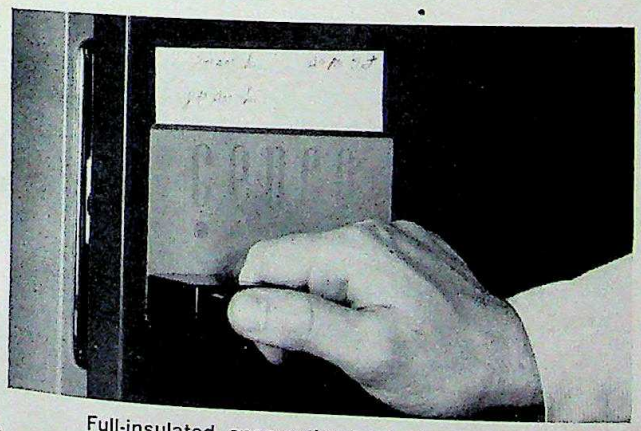
- two light weight, adjustable shelves
- fully shielded Incoloy heater elements
- temperature uniformity within 1.5° C
- completely grounded by 3-wire line cord
- choice of gravity or forced air circulation
- available with corrosion resistant aluminum liner

Pick the model that fits your needs from this chart—

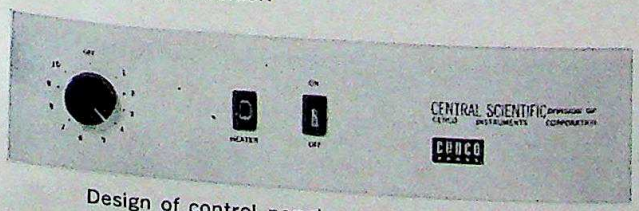
	CENCO NO.	INTERIOR	DIMENSIONS (W" x D" x H") INSIDE	OUTSIDE	ELECTRICAL VOLTAGE	CURRENT	WATTAGE	PRICE EACH
Gravity These ovens have a temperature to 200°C with a material uniformity of ±1.5°C.	95077-16	LACQUERED STEEL	14 x 14 x 14	18 x 17½ x 26	115	50/60 AC	750	$185.00
	95077-17		14 x 14 x 14	18 x 17½ x 26	230	50/60 AC	750	197.00
	95078-16	ALUMINUM	14 x 14 x 14	18 x 17½ x 26	115	50/60 AC	750	195.00
	95078-17		14 x 14 x 14	18 x 17½ x 26	230	50/60 AC	750	207.00
	95085-16	LACQUERED STEEL	19 x 17 x 20	23 x 21 x 32	115	50/60 AC	1200	245.00
	95085-17		19 x 17 x 20	23 x 21 x 32	230	50/60 AC	1200	257.00
	95086-16	ALUMINUM	19 x 17 x 20	23 x 21 x 32	115	50/60 AC	1200	250.00
	95086-17		19 x 17 x 20	23 x 21 x 32	230	50/60 AC	1200	262.50
Forced Draft These ovens have a temperature to 200°C with a material uniformity of ±1°C.	95377-16	LACQUERED STEEL	13 x 13½ x 14	18 x 17½ x 25¼	115	50/60 AC	750	$235.00
	95377-17		13 x 13½ x 14	18 x 17½ x 25¼	230	50/60 AC	750	250.00
	95378-16	ALUMINUM	13 x 14 x 14	18 x 17½ x 26	115	50/60 AC	750	245.00
	95378-17		13 x 14 x 14	18 x 17½ x 26	230	50/60 AC	750	260.00
	95395-16	LACQUERED STEEL	18 x 16½ x 20	23 x 21 x 32	115	50/60 AC	1200	315.00
	95395-17		18 x 16½ x 20	23 x 21 x 32	230	50/60 AC	1200	332.50
	95396-16	ALUMINUM	18 x 17 x 20	23 x 21 x 32	115	50/60 AC	1200	325.00
	95396-17		18 x 17 x 20	23 x 21 x 32	230	50/60 AC	1200	337.50



Long-lasting silicon rubber door gasket insures positive seal.



Full-insulated, snap-action latch also serves as handy card holder.



Design of control panel permits easy setting, monitoring and adjustment of temperatures.

CENTRAL SCIENTIFIC

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Santa Clara, Calif., 1040 Martin Ave.
Montreal 14, Quebec, 7275 St. Urbain St.
Vancouver 3, B. C., 1206 Homer St.
Birmingham 4, Ala., 3232 Eleventh Ave., N.
Tulsa 12, Okla., 6901 East 12th St.
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alyzer originally developed for use at the British Atomic Energy Research Establishment at Harwell and marketed by Mervyn Instruments, Britain—a subsidiary of Gulton.

● Order the following from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C.:

Standard X-Ray Diffraction Powder Patterns, by Howard E. Swanson, Marlene C. Morris, Roger Stinchfield, and Eloise H. Evans, National Bureau of Standards Monograph 25, Section 2; May 3, 1963; 46 pages; 35 cents.

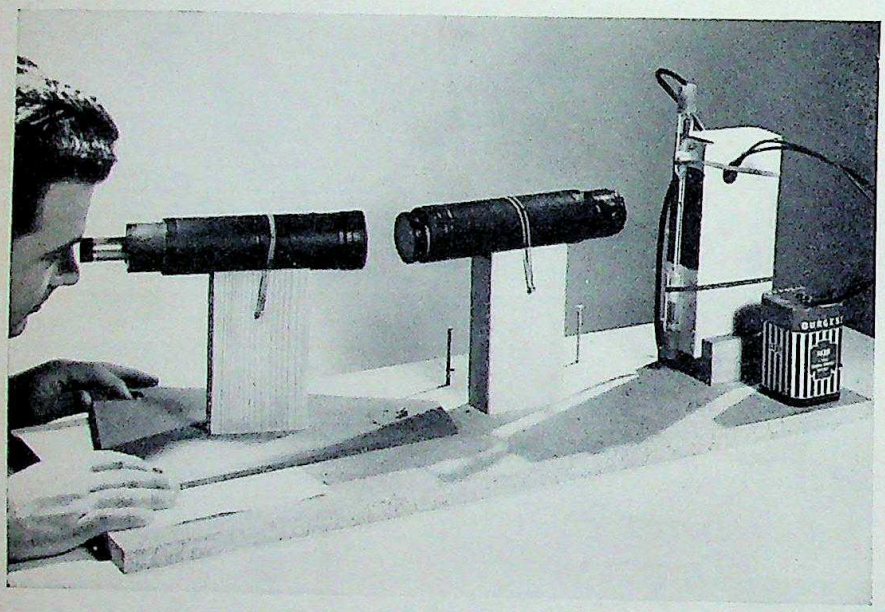
Lectures on Ion-Atom Collisions, by M. R. C. McDowell; National Bureau of Standards Technical Note 185; March 15, 1963; 66 pages; 40 cents.

● Wilkens Instrument & Research of Walnut Creek, California, announces its latest, most complete Gas Chromatography Accessory Catalog. A special feature for the chemist is a section on "General Column Applications," where various stationary phases have been compiled, and listed as to type of compound and recommended maximum operating temperature. Photographs, drawings and specifications show the complete Aerograph line of accessories, supplies and materials, which include many GC items exclusive with Wilkens. The entire catalog was designed as a quick and easy reference for the busy GC chemist. For a free copy of this new catalog, and also a free subscription to Aerograph Research Notes, and Previews and Reviews, monthly house publications, send name and company address to Wilkens Instrument & Research, Inc., P.O. Box 313, Walnut Creek, Calif.

● An informative new catalog describing the function of the Cartesian Manostat in vacuum, pressure and flow control has just been published by Manostat Corporation, 20 N. Moore Street, New York 13, N. Y. It is available without cost upon request. The publication outlines the background, development and mechanical concept of the patented Cartesian Manostat. Detailed data are provided concerning the many and varied applications of the instrument in vacuum control, pressure control and flow regulation. Included in the catalog are illustrations and detailed specifications of the complete line of Cartesian Manostats.

● A recent published bulletin on newly designed glass chromatographic column and accessories is currently available from the Kontes Glass Company. Featuring the Chromaflex line of separable columns, this bulletin lists complete prices, specifications, and other useful descriptive information. For the complete story write for a free copy of Bulletin CA-1, Kontes Glass Company, 126 Spruce Street, Vineland, New Jersey.

NEW ESI-APPROVED SPECTROMETER



MSC Catalog No. 3900 Spectrometer for use in the PSSC Advanced Topics program. A high-quality optical system with a precise adjustable slit and a 15,000-lines-per-inch quality replica grating are the essential elements of Macalaster Scientific's new precision student Spectrometer. Spectral lines can be determined to an accuracy of plus or minus 10 Angstroms, using known lines as a standard. Measurement of the Balmer lines of hydrogen permits the calculation at both Rydberg's and Planck's constants. $35.00

Spectral line sources are operated by
MSC Catalog No. 1300 High Voltage Source **$7.50**
Illustrated with: No. 390-31 Helium Tube **3.00**

MACALASTER
SCIENTIFIC CORPORATION
EDUCATIONAL DIVISION
253 NORFOLK ST.
CAMBRIDGE 39, MASSACHUSETTS

New Chemicals

◇ Four thousand packaged chemicals of the British Drug Houses, Ltd. are now stocked and catalogued by The Ealing Corp., 2224 Massachusetts Ave., Cambridge 40, Massachusetts. The 1963 BDH Catalogue lists a wide range of inorganics, microanalytical reagents, organic analytical standards, and materials for chromatography.

◇ Beta-cyclodextrin acetate is now available from Applied Science Laboratories, Inc., State College, Pennsylvania. Schlenk, Gellerman and Sand, Anal. Chemistry., *34*, 1529–1532 (1962), found this material particularly suited as a stationary phase for preparative scale gas chromatography of fatty acid methyl esters.

◇ More than 400 "off-the-shelf" radioactive chemicals, radioisotope compounds and reference sources are described in a new Radiochemical Catalogue and Price List just released by the Tracerlab Division of Laboratory For Electronics, Inc. Included is complete information on purity, shelf life, specific activity, price, minimum orders. For a copy, write to: Department PIO, Tracerlag, 1601 Trapelo Rd., Waltham 54, Massachusetts.

◇ A new air-dry vinyl spray has been introduced by Manostat Corp., a subsidiary of Greiner Scientific Corporation, 26 North Moore St., New York 13, N. Y. Packaged in handy push-button aerosol spray cans under the brand name *Quelspray*, the new product, a durable vinyl coating, has been proved better than paint to protect plant equipment, laboratory containers and bottles.

(*Continued on page A654*)

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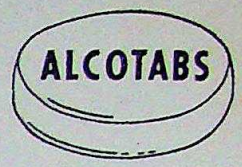
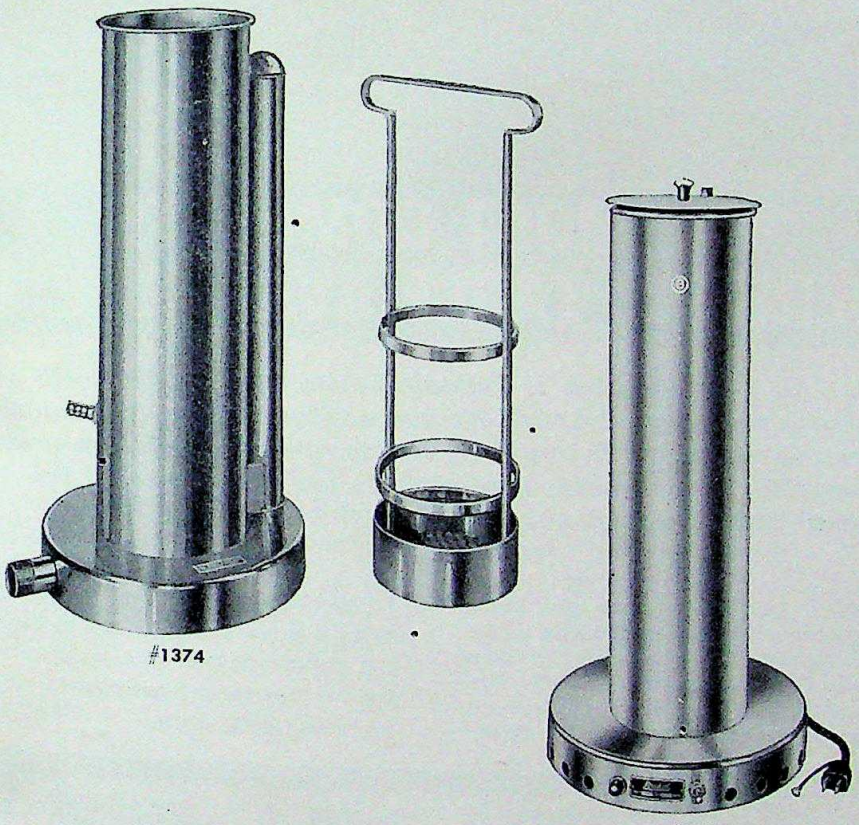
THE MODERN WAY *of cleaning and drying pipettes*

Boekel PIPETTE WASHER *and* PIPETTE DRYER



THE BOEKEL PIPETTE WASHER provides a continuous supply of fresh clear water that flows through the fragile pipettes cleaning them quickly and safely. The washing cycle is silent, automatic and continuous—operating even with a low volume of water.

THE BOEKEL PIPETTE DRYER circulates hot air to completely evaporate moisture from all surfaces of the pipettes. Approximately one hour is required for the drying operation. Moisture is released through vented top.



#1374

#1372

1374—Pipette Washer, stainless steel, 22½" high by 6" diameter with 10½" diameter base. Includes stainless steel pipette holder. Will hold pipettes up to 375 mm. in length.
#1374 Stainless Steel Washer with Pipette Rack.....$66.95 ea.

1372—Pipette Dryer, stainless steel, 23¼" high by 5½" diameter with 10½" diameter base. Heated by 225 watt, 115 volt unit with toggle switch control. Neon Pilot light and safety 3-wire rubber covered cord with grounded plug.
#1372 Stainless Steel Dryer (without rack).....$47.00 ea.

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#216

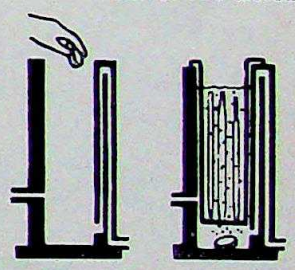
world's best detergent . . . in TABLET FORM!

to effectively remove the most stubborn foreign matter

Here's the best way to clean a full load of pipettes in one easy operation! ALCOTABS improve the washing action of your washer AT A COST OF ONLY 5¢ for a Complete Load. One ALCOTAB releases a controlled amount of detergent solution, within the first 8 to 10 cycles, as the water flows through and around the pipettes insuring thorough cleaning. After the ALCOTAB has been consumed, rinsing follows *automatically*... leaving film-free, sparkling-clean pipettes.

Faster, more efficient ALCOTABS remove even the most stubborn foreign matter, blood, serum, etc., in either warm or cold...hard or soft water. Order a supply of new ALCOTABS today!

Box of 100 tablets $5.00



1. **Drop one Alcotab into Pipette Washer.**
2. **Place holder with Pipettes into washer.**
3. **Turn on either cold or warm water.**
4. **After the Alcotab has dissolved, allow to rinse in the usual manner.**

Order a box today from your supplier—or send for samples and literature.

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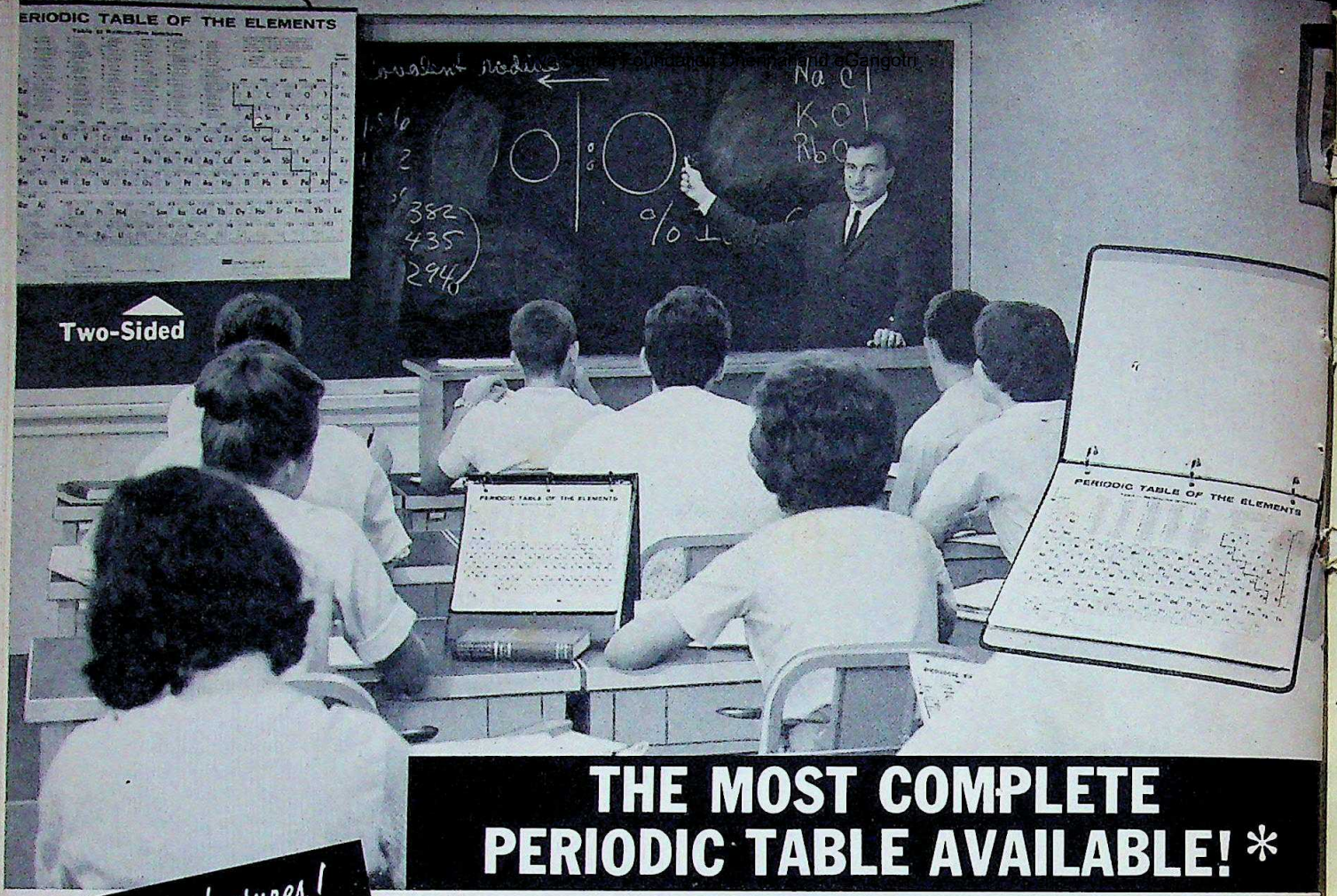

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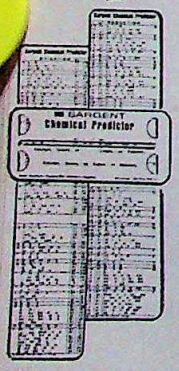

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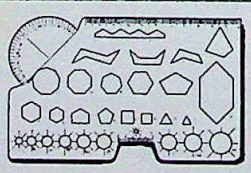

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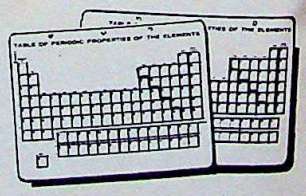

BLANK FORMS OF PERIODIC TABLE
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PERIODIC TABLE OF THE ELEMENTS

Table of Radioactive Isotopes

Naturally occurring radioactive isotopes are indicated by a blue mass number. Half lives are in parentheses where s, m, h, d and y stand for seconds, minutes, hours, days and years respectively. The symbols describing the mode of decay and resulting radiation are defined as follows:

α	alpha particle	L	L-electron capture
β^-	beta particle	SF	spontaneous fission
β^+	positron	γ	gamma ray
K	K-electron capture	e^-	internal electron conversion

Ac 227(22y)β^-,α
Ag 110(24s)β^-,γ
111(7.5d)β^-,γ
Am241(470y)α,γ,e^-
242(100y)β^-,K,α,γ
243(8000y)α,γ
As 76(26.7h)β^-,γ
77(39h)β^-,γ
At 210(8.3h)K,α,γ
211(7.5h),Kα,γ
Au 198(2.69d)β^-,γ
Ba 131(12d)K,γ
133(7.5y)K,γ,e^-
Bi 210(5d)β^-,α
Bk 245(4.9d)K,α,γ
249(290d)β^-,α,SF
Br 82(36h)β^-,γ
C 14(5600y)β^-
Ca 41(1×10^5y)K
45(160d)β^-
47(4.7d)β^-,γ
Cd 115(43d)β^-,γ
Ce 141(32d)β^-,γ
143(33h)β^-,γ
144(285d)β^-,γ
Cf 246(35h)α,γ,SF
249(500y)α,γ,SF
251(700y)γ
Cl 36(3×10^5y)β^-
Cm 243(35y),α,γ
245(11000y),α,γ
247(1y)
Co 58(71d),K,β^+,γ
60(5.27y)K,γ,e^-
Cr 51(27d),K,γ
Cs 134(2.2y)β^-,γ
135(3×10^6y)β^-
137(30y)β^-,γ
Cu 64(12.8h)K,β^-,β^+,γ
Es 253(20d)α,γ,SF
254(1y)α,SF
Eu 154(16y)β^-,γ
155(1.7y)β^-,γ
Fe 55(2.9y)K
59(45d)β^-,γ
Fm 255(20h)α
Fr 223(22m)β^-,γ,α
Ga 72(14.1h),β^-,γ
Gd 153(236d)K,γ,e^-
159(18h)β^-,γ
Ge 71(11d)K
H 3(12.3y)β^-
Hf 181(45d)β^-,γ,e^-
Hg 197(65h)K,γ,e^-
203(47d)β^-,γ,e^-
Ho 166(27.3h)β^-,γ
I 129(1$0^7$y)β^+,γ,e
131(8.05d)β^-,γ
In 114(50d)γ
Ir 192(74.4d)β^-,γ
K 40(1$0^9$y)β^+,K,γ
42(12.4h),β^-,γ
La 140(40.2h)β^-,γ
Lu 176(1$0^{10}$y)β^-,K,γ
177(6.8d)β^-,γ
Md 256(30m)K,SF
Mo 99(67h)β^-,γ
Na 22(2.6y)β^+,K,γ
24(15h)β^-,γ
Nd 147(11.1d)β^-,γ
Ni 63(125y)β^-
59(8×10^4y),K
Np 237(2.2×10^6y)α,γ
239(2.33d)β^-,γ
Os 191(15d)β^-,γ,e^-
P 32(14.2d)β^-
Pa 231(34000y)α,γ
Pb 210(19.4y)β^-,γ,e^-
202(10^5y)L
Pd 103(17d)K,γ
Pm 147(2.6y)β^-
145(25y)K,L,α
Po 210(138.4d)α,γ
209(100y)α,K,γ
Pr 143(13.8d)β^-
Pt 197(18h)β^-,γ
Pu 242(3.8 × 10^5y)α,SF
241(13y)β^-,α,γ
239(24300y)α,γ,SF
Ra 226(1620y)α,γ
Rb 86(18.6h)β^-,γ
Re 188(16.7h)β^-,γ
186(3.7d)β^-,γ
Rn 222(3.82d)α
Ru 103(40d)β^-,γ
97(2.9d),K,γ,e^-
S 35(87d)β^-
Sb 122(2.8d)β^-,K,β^+,γ
124(60d)β^-,γ
Sc 46(84d)β^-,γ
Se 75(121d)K,γ
Sm 153(47h)β^-,γ
145(340d)K,γ
Sn 113(119d)K,L,γ,e^-
Sr 90(28y)β^-
89(51d)β^-,γ
85(64d)K,γ
Ta 182(115d)β^-,γ
Tb 160(73d)β^-γ
Tc 99(2×10^5y)β^-
97(10^5y)K
Te 127(9.3h)β^-
Th 232(1.4×10^{10}y)α,γ,SF
228(1.91y)β^-
Tl 204(3.56y)β^-,K
Tm 170(127d)β^-,γ,e^-
U 238(4.5×10^9y)α,γ,SF
234(2.5×10^5y)α,γ,SF
235(7.1×10^8y)α,γ,SF
233(1.6×10^5y)α,γ
W 185(73d)β^-,γ
Y 90(64h)β^-,e^-
Yb 175(4.2d)β^-γ
169(31d)K,γ,e^-
Zn 65(245d)K,β^+,γ
Zr 95(65d)β^-,γ,e^-
93(9×10^5y)β^-,γ

PERIOD	GROUP IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	INERT GASES
1	1 1.00797 1 −252.7 −259.2 0.071 s^1 H Hydrogen																	2 4.0026 0 −268.9 −269.7 0.126 s^2 He Helium
2	3 6.939 1 1330 108.5 0.53 $s^2 2s^1$ Li Lithium	4 9.0122 2 2770 1277 1.85 $s^2 2s^2$ Be Beryllium											5 10.811 3 — (2030) 2.34 $s^2 2s^2 2p^1$ B Boron	6 12.0111 ±4,2 4830 3727g 2.26 $s^2 2s^2 2p^2$ C Carbon	7 14.0067 ±3,5,4,2 −195.8 −210 0.81 $s^2 2s^2 2p^3$ N Nitrogen	8 15.9994 −2 −183 −218.8 1.14 $s^2 2s^2 2p^4$ O Oxygen	9 18.9984 −1 −188.2 −219.6 1.11 $s^2 2s^2 2p^5$ F Fluorine	10 20.183 0 −246 −248.6 [illegible] $s^2 2s^2 2p^6$ Ne Neon
3	11 22.9898 1 892 97.8 0.97 [Ne]$3s^1$ Na Sodium	12 24.312 2 1107 650 1.74 [Ne]$3s^2$ Mg Magnesium											13 26.9815 3 2450 660 2.70 [Ne]$3s^2 3p^1$ Al Aluminum	14 28.086 4 2680 1410 2.33 [Ne]$3s^2 3p^2$ Si Silicon	15 30.9738 ±3,5,4 280w 44.2w 1.82w [Ne]$3s^2 3p^3$ P Phosphorus	16 32.064 6,3,4,−2 444.6 119.0 2.07 [Ne]$3s^2 3p^4$ S Sulfur	17 35.453 ±1,4,5,6,7 −34.7 −101.0 1.56 [Ne]$3s^2 3p^5$ Cl Chlorine	18 39.948 0 −185.8 −189.4 [illegible] [Ne]$3s^2 3p^6$ Ar Argon
4	19 39.102 1 760 63.7 0.86 [Ar]$4s^1$ K Potassium	20 40.08 2 1440 838 1.55 [Ar]$4s^2$ Ca Calcium	21 44.956 3 2730 1539 3.0 [Ar]$3d^1 4s^2$ Sc Scandium	22 47.90 4,3 3260 1668 4.51 [Ar]$3d^2 4s^2$ Ti Titanium	23 50.942 5,4,3,2, 3450 1900 6.1 [Ar]$3d^3 4s^2$ V Vanadium	24 51.996 6,3,2 2665 1875 7.19 [Ar]$3d^5 4s^1$ Cr Chromium	25 54.938 7,6,4,2,3 2150 1245 7.43 [Ar]$3d^5 4s^2$ Mn Manganese	26 55.847 2,3 3000 1536 7.86 [Ar]$3d^6 4s^2$ Fe Iron	27 58.933 2,3 2900 1495 8.9 [Ar]$3d^7 4s^2$ Co Cobalt	28 58.71 2,3 2730 1453 8.9 [Ar]$3d^8 4s^2$ Ni Nickel	29 63.54 2,1 2595 1083 8.96 [Ar]$3d^{10} 4s^1$ Cu Copper	30 65.37 2 906 419.5 7.14 [Ar]$3d^{10} 4s^2$ Zn Zinc	31 69.72 3 2237 29.8 5.91 [Ar]$3d^{10} 4s^2 4p^1$ Ga Gallium	32 72.59 4 2830 937.4 5.32 [Ar]$3d^{10} 4s^2 4p^2$ Ge Germanium	33 74.922 ±3,5 613* 817 5.72 [Ar]$3d^{10} 4s^2 4p^3$ As Arsenic	34 78.96 6,4,−2 685 217 4.79 [Ar]$3d^{10} 4s^2 4p^4$ Se Selenium	35 79.909 ±1,4,5 58 −7.2 3.12 [Ar]$3d^{10} 4s^2 4p^5$ Br Bromine	36 83.80 0 −157 −163 [illegible] [Ar]$3d^{10} 4s^2 4p^6$ Kr Krypton
5	37 85.47 1 688 38.9 1.53 [Kr]$5s^1$ Rb Rubidium	38 87.62 2 1380 768 2.6 [Kr]$5s^2$ Sr Strontium	39 88.905 3 2927 1509 4.47 [Kr]$4d^1 5s^2$ Y Yttrium	40 91.22 4 3580 1852 6.49 [Kr]$4d^2 5s^2$ Zr Zirconium	41 92.906 5,3 3300 2415 8.4 [Kr]$4d^4 5s^1$ Nb Niobium	42 95.94 6,5,4,3,2 5560 2610 10.2 [Kr]$4d^5 5s^1$ Mo Molybdenum	43 (99) 7 — 2200 11.5 [Kr]$4d^5 5s^2$ Tc Technetium	44 101.07 2,3,4,6,8 4900 2500 12.2 [Kr]$4d^7 5s^1$ Ru Ruthenium	45 102.905 2,3,4 4500 1966 12.4 [Kr]$4d^8 5s^1$ Rh Rhodium	46 106.4 2,4 3980 1552 12.0 [Kr]$4d^{10} 5s^0$ Pd Palladium	47 107.870 1 2210 960.8 10.5 [Kr]$4d^{10} 5s^1$ Ag Silver	48 112.40 2 765 320.9 8.65 [Kr]$4d^{10} 5s^2$ Cd Cadmium	49 114.82 3 2000 156.2 7.31 [Kr]$4d^{10} 5s^2 5p^1$ In Indium	50 118.69 4,2 2270 231.9 7.30 [Kr]$4d^{10} 5s^2 5p^2$ Sn Tin	51 121.75 ±3,5 1380 630.5 6.62 [Kr]$4d^{10} 5s^2 5p^3$ Sb Antimony	52 127.60 6,4,−2 989.8 449.5 6.24 [Kr]$4d^{10} 5s^2 5p^4$ Te Tellurium	53 126.904 ±1,4,5,7 183 113.7 4.94 [Kr]$4d^{10} 5s^2 5p^5$ I Iodine	54 131.30 0 −111.9 −163.6 3.5 [Kr]$4d^{10} 5s^2 5p^6$ Xe Xenon
6	55 132.905 1 690 28.7 1.90 [Xe]$6s^1$ Cs Cesium	56 137.34 2 1640 714 3.5 [Xe]$6s^2$ Ba Barium	57 138.91 3 ★ 3470 920 6.17 [Xe]$5d^1 6s^2$ La Lanthanum	72 178.49 4 5400 2222 13.1 [Xe]$4f^{14} 5d^2 6s^2$ Hf Hafnium	73 180.948 5 5425 2996 16.6 [Xe]$4f^{14} 5d^3 6s^2$ Ta Tantalum	74 183.85 6,5,4,3,2 5930 3410 19.3 [Xe]$4f^{14} 5d^4 6s^2$ W Wolfram	75 186.2 7,6,4,2,−1 5900 3180 21.0 [Xe]$4f^{14} 5d^5 6s^2$ Re Rhenium	76 190.2 2,3,4,6,8 5500 2700 22.6 [Xe]$4f^{14} 5d^6 6s^2$ Os Osmium	77 192.2 2,3,4,6 5300 2454 22.5 [Xe]$4f^{14} 5d^7 6s^2$ Ir Iridium	78 195.09 2,4 4530 1769 21.4 [Xe]$4f^{14} 5d^9 6s^1$ Pt Platinum	79 196.967 3,1 2970 1063 19.3 [Xe]$4f^{14} 5d^{10} 6s^1$ Au Gold	80 200.59 2,1 357 −38.4 13.6 [Xe]$4f^{14} 5d^{10} 6s^2$ Hg Mercury	81 204.37 3,1 1457 303 11.85 [Xe]$4f^{14} 5d^{10} 6s^2 6p^1$ Tl Thallium	82 207.19 4,2 1725 327.4 11.4 [Xe]$4f^{14} 5d^{10} 6s^2 6p^2$ Pb Lead	83 208.980 3,5 1560 271.3 9.8 [Xe]$4f^{14} 5d^{10} 6s^2 6p^3$ Bi Bismuth	84 (210) 4,2 — 254 (9.2) [Xe]$4f^{14} 5d^{10} 6s^2 6p^4$ Po Polonium	85 (210) — — (302) — [Xe]$4f^{14} 5d^{10} 6s^2 6p^5$ At Astatine	86 (222) 0 (−71) (−71) [illegible] [Xe]$4f^{14} 5d^{10} 6s^2 6p^6$ Rn Radon
7	87 (223) 1 — (27) — [Rn]$7s^1$ Fr Francium	88 (226) 2 — 700 5.0 [Rn]$7s^2$ Radium	89 ★★ (227) 3 — 1050 — [Rn]$6d^1 7s^2$ Ac Actinium															

★	58 140.12 3,4 3468 795 6.67 [Xe]$4f^1 5d^1 6s^2$ Ce Cerium	59 140.907 3,4 3127 935 6.77 [Xe]$4f^3 5d^0 6s^2$ Pr Praseodymium	60 144.24 3 3027 1024 7.00 [Xe]$4f^4 5d^0 6s^2$ Nd Neodymium	61 (147) 3 — (1027) — [Xe]$4f^5 5d^0 6s^2$ Pm Promethium	62 150.35 3,2 1900 1072 7.54 [Xe]$4f^6 5d^0 6s^2$ Sm Samarium	63 151.96 3,2 1439 826 5.26 [Xe]$4f^7 5d^0 6s^2$ Eu Europium	64 157.25 3 3000 1312 7.89 [Xe]$4f^7 5d^1 6s^2$ Gd Gadolinium	65 158.924 3,4 2800 1356 8.27 [Xe]$4f^9 5d^0 6s^2$ Tb Terbium	66 162.50 3 2600 1407 8.54 [Xe]$4f^{10} 5d^0 s^2$ Dy Dysprosium	67 164.930 3 2600 1461 8.80 [Xe]$4f^{11} 5d^0 6s^2$ Ho Holmium	68 167.26 3 2900 1497 9.05 [Xe]$4f^{12} 5d^0 6s^2$ Er Erbium	69 168.934 3,2 1727 1545 9.33 [Xe]$4f^{13} 5d^0 6s^2$ Tm Thulium	70 173.04 3,2 1427 824 6.98 [Xe]$4f^{14} 5d^0 6s^2$ Yb Ytterbium	71 174.97 3 3327 1652 9.84 [Xe]$4f^{14} 5d^1 6s^2$ Lu Lutetium
★★	90 232.038 4 3850 1750 11.7 [Rn]$6d^2 7s^2$ Th Thorium	91 (231) 5,4 — (1230) 15.4 [Rn]$5f^2 6d^1 7s^2$ Pa Protactinium	92 238.04 6,5,4,3 3818 1132 19.07 [Rn]$5f^3 6d^1 7s^2$ U Uranium	93 (237) 6,5,4,3 — 637 19.5 [Rn]$5f^4 6d^0 7s^2$ Np Neptunium	94 (242) 6,5,4,3 3235 640 — [Rn]$5f^6 6d^0 7s^2$ Pu Plutonium	95 (243) 6,5,4,3 — — 11.7 [Rn]$5f^7 6d^0 7s^2$ Am Americium	96 (247) 3 — — — [Rn]$5f^7 6d^1 7s^2$ Cm Curium	97 (247) 4,3 — — — [Rn]$5f^9 6d^0 7s^2$ Bk Berkelium	98 (251) 3 — — — [Rn]$5f^{10} 6d^0 7s^2$ Cf Californium	99 (254) — — — — [Rn]$5f^{11} 6d^0 7s^2$ Es Einsteinium	100 (253) — — — — Fm Fermium	101 (256) — — — — Md Mendelevium	102 (254) — — — — No Nobelium	103 (257) — — — — (Lw) See note 3 (Lawrencium)

KEY

ATOMIC NUMBER — ATOMIC WEIGHT (2) — OXIDATION STATES (Bold most stable) — BOILING POINT, °C — MELTING POINT, °C — DENSITY (g/ml) (4) — SYMBOL (1) — ELECTRON STRUCTURE — NAME

30 65.37 2 906 419.5 7.14 Zn [Ar]$3d^{10} 4s^2$ Zinc

NOTES:

(1) Black — solid.
Red — gas.
Blue — liquid.
Outline — synthetically prepared.

(2) Based upon carbon – 12. ( ) indicates most stable or best known isotope.

(3) Proposed; not officially accepted

SIDE 1

SARGENT
E. H. SARGENT & CO. SCIENTIFIC LABORATORY EQUIPMENT
CHICAGO DETROIT DALLAS BIRMINGHAM SPRINGFIELD, N. J. ANAHEIM, CALIF.

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TABLE OF PERIODIC PROPERTIES OF THE ELEMENTS

Percent Ionic Character of a Single Chemical Bond

Difference in electronegativity	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
Percent ionic character %	0.5	1	2	4	6	9	12	15	19	22	26	30	34	39	43	47	51	55	59	63	67	70	74	76	79	82	84	86	88	89	91	92

Sub-Atomic Particles

	Electron	Positron	Proton	Neutron	Photon	Neutrino	Meson					Hyperon			
Symbol	e^-, β^-	e^+, β^+	↑p	↑n	γ	↑ν	$\mu^\pm$	$\pi^\pm$	↑π^0	↑K^+	↑K^0	↑Λ^0	↑Σ^+	↑Σ^-	↑Ξ^-
Mass*	1	1	1836.12	1838.65	0	−0	206.84	273.23	264.4	966.6	974.4	2181.4	2327.7	2343.2	2584
Charge**	−1	+1	+1	0	0	0	±1	±1	0	+1	0	0	+1	−1	−1
Spin	½	½	½	½	1	½	½	0	0	0	0	½	½-integral	½-integral	½-integral
Magnetic Moment	1.00 B.m.	1.00 B.m.	2.793 n.m.	−1.913 n.m.	0	−0		0	0						
Mean Life (sec.)	stable	stable	stable	1.11×10^3	stable	stable	2.22×10^{-6}	2.54×10^{-8}	$\sim10^{-15}$	$\sim10^{-8}$	$\sim10^{-10}$–10^{-7}	2.8×10^{-10}	$\sim5\times10^{-11}$	$\sim10^{-10}$	$\sim10^{-10}$
Decay Modes				$\rightarrow p+e^-+\bar{\nu}$			$\rightarrow e^\pm+\nu+\bar{\nu}$	$\rightarrow\mu^\pm+\nu$	$\rightarrow\gamma+\gamma$; $e^++e^-+\gamma$	complex	complex	$\rightarrow p+\pi^-$; $n+\pi^0$	$\rightarrow p+\pi^0$; $n+\pi^+$	$\rightarrow n+\pi^-$	$\rightarrow\Lambda^0+\pi^-$

B.m. = Bohr magneton n.m. = Nuclear magneton *In units of 9.1083×10^{-31} kg. **In units of 4.80286×10^{-10} esu. †Exists as an antiparticle not listed.

PERIOD — GROUP IA, IIA, IIIB, IVB, VB, VIB, VIIB, VIII, IB, IIB, IIIA, IVA, VA, VIA, VIIA, INERT GASES

Symbol	Atomic Number	Atomic Weight	Electronegativity (Pauling's)	Heat of Vaporization (kg-cal/g-atom) (*,5)	Heat of Fusion (kg-cal/g-atom)	Electrical Conductance (6) (microhms)*1	Thermal Conductance	Specific Heat (cal/g/°c)	First Ionization Energy (kcal/g-mole)	Covalent Radius, Å	Ionic Radius, Å (7)	Atomic Radius, Å (8)	Atomic Volume, W/D
H	1	1.00	2.1	0.108	0.014	—	—	3.45	.0004	0.37	—	14.1	313
He	2	4.00	—	0.020	0.005	—	—	—	—	0.93	—	31.8	567
Li	3	6.94	1.0	32.48	0.72	0.108	0.17	0.79	124	1.34	0.60(+1)	13.1	1.55
Be	4	9.01	1.5	73.9	2.8	0.25	0.38	0.45	215	0.90	0.31(+2)	5.0	1.12
B	5	10.81	2.0	75	5.3	10^{-12}	—	0.309	191	0.82	0.20(+3)	4.6	0.98
C	6	12.01	2.5	171.7*	—	.0007	0.057	0.165	260	0.77	0.15(+4)	5.3	0.914
N	7	14.01	3.0	0.666	0.086	.00006	0.247	0.218	336	0.75	0.11(+3)	17.3	0.92
O	8	16.00	3.5	0.815	0.053	.00006	0.218	0.218	314	0.73	1.40(−2)	14.0	0.09(+6)
F	9	19.00	4.0	0.755	0.061	—	0.18	0.18	402	0.72	1.36(−1)	17.1	0.07(+7)
Ne	10	20.183	—	0.431	0.080	—	—	.0001	497	1.31	—	16.8	—
Na	11	22.99	0.9	24.12	0.218	0.32	0.295	0.295	119	1.54	0.95(+1)	23.7	1.90
Mg	12	24.32	1.2	32.517	2.14	0.224	0.38	0.25	176	1.30	0.65(+2)	14.0	1.60
Al	13	26.98	1.5	67.9	2.55	0.382	0.50	0.215	138	1.18	0.50(+3)	10.0	1.43
Si	14	28.09	1.8	(40.6)	11.1	0.10	0.20	0.162	188	1.11	0.41(+4)	12.1	1.32
P	15	30.97	2.1	2.97	0.15	10^{-17}	—	0.177	254	1.06	0.34(+5)	17.0	1.28
S	16	32.06	2.5	3.01*	0.34	10^{-23}	.0007	0.175	239	1.02	1.84(−2)	15.5	1.27
Cl	17	35.453	3.0	2.44	0.77	—	.00002	0.116	300	0.99	1.81(−1)	18.7	0.26(+7)
Ar	18	39.948	—	1.56	0.281	—	.00004	0.125	363	1.74	—	24.2	—
K	19	39.102	0.8	18.9	0.55	0.143	0.23	0.177	100	1.96	1.33(+1)	45.3	2.35
Ca	20	40.08	1.0	36.74	2.1	0.218	0.3	0.149	141	1.74	0.99(+2)	29.9	1.97
Sc	21	44.96	1.3	81	3.8	0.015	0.15	0.13	151	1.44	0.81(+3)	15.0	1.62
Ti	22	47.90	1.5	106.5*	3.7	0.024	—	0.126	158	1.36	0.90(+2)	10.6	1.47
V	23	50.94	1.6	106	4.2	0.04	—	0.120	156	1.34	0.74(+3)	8.35	0.59(+5)
Cr	24	52.01	1.6	72.97	3.3	0.078	0.16	0.11	156	1.27	0.69(+3)	7.23	0.52(+6)
Mn	25	54.94	1.5	53.7	3.50	0.054	—	0.115	171	1.26	0.80(+2)	7.39	0.46(+7)
Fe	26	55.85	1.8	84.6	3.67	0.10	0.18	0.11	182	1.26	0.76(+2)	7.1	0.64(+3)
Co	27	58.93	1.8	93	3.64	0.16	0.16	0.099	181	1.25	0.78(+2)	6.7	0.63(+3)
Ni	28	58.71	1.8	91.0	4.21	0.145	0.22	0.105	176	1.24	0.78(+2)	6.6	0.62(+3)
Cu	29	63.54	1.9	72.8	3.11	0.593	0.94	0.092	178	1.38	0.96(+1)	7.1	0.69(+2)
Zn	30	65.38	1.6	27.4	1.76	0.167	0.27	0.0915	216	1.31	0.74(+2)	9.2	—
Ga	31	69.72	1.6	—	1.34	.058	0.079	0.079	138	1.26	1.48(+1)	11.8	0.62(+3)
Ge	32	72.59	1.8	68	7.6	0.022	0.14	0.073	187	1.22	0.93(+2)	13.6	0.53(+4)
As	33	74.92	2.0	7.75*	6.62	0.029	—	0.082	231	1.19	1.39	13.1	2.22(−3)
Se	34	78.96	2.4	3.34	1.25	0.08	.00001	0.084	225	1.16	1.40	16.5	0.42(+4)
Br	35	79.904	2.8	—	1.26	10^{-18}	—	0.070	273	1.14	—	23.5	1.95(−1)
Kr	36	83.80	—	2.16	0.39	—	.00002	—	323	1.89	—	32.2	—
Rb	37	85.47	0.8	18.1	0.55	0.080	—	0.080	96	2.11	1.48(+1)	55.9	2.48
Sr	38	87.62	1.0	33.8	2.1	0.043	—	0.176	131	1.92	1.13(+2)	33.7	—
Y	39	88.905	1.3	93	2.7	0.019	0.035	0.071	152	1.62	0.93(+3)	19.8	1.80
Zr	40	91.22	1.4	120	4.0	0.024	—	0.066	160	1.48	0.80(+4)	14.1	1.60
Nb	41	92.906	1.6	—	6.4	0.080	0.125	0.065	156	1.46	0.70(+5)	10.8	—
Mo	42	95.94	1.8	128	6.6	0.19	0.35	0.061	166	1.39	0.68(+4)	9.4	0.62(+6)
Tc	43	(98)	1.9	120	—	—	—	—	167	1.36	—	—	—
Ru	44	101.07	2.2	148	6.1	0.10	—	0.057	173	1.34	0.69(+3)	8.3	0.65(+4)
Rh	45	102.905	2.2	127	5.2	—	0.22	0.059	178	1.34	0.86(+3)	8.3	—
Pd	46	106.42	2.2	90	4.0	0.093	0.17	0.058	192	1.37	0.50(+2)	8.9	—
Ag	47	107.868	1.9	60.7	2.70	0.616	0.98	0.056	175	1.53	1.44	10.3	—
Cd	48	112.41	1.7	23.9	1.46	0.146	0.22	0.055	207	1.48	1.54	13.1	0.97(+2)
In	49	114.82	1.7	53.7	0.78	0.057	0.057	0.057	133	1.44	1.32(+1)	15.7	0.81(+3)
Sn	50	118.69	1.8	70	1.72	0.088	0.16	0.054	169	1.41	1.12(+2)	16.3	0.71(+4)
Sb	51	121.75	1.9	46.6	4.74	0.026	0.05	0.049	199	1.38	2.45(−3)	18.4	0.62(+5)
Te	52	127.60	2.1	11.9	4.28	10^{-6}	0.014	0.047	208	1.35	2.21(−2)	20.5	0.56(+6)
I	53	126.904	2.5	5.2	1.87	10^{-14}	.001	0.052	241	1.33	—	25.7	2.16(−1)
Xe	54	131.29	—	3.07	0.55	—	.0001	—	280	2.09	—	42.9	0.50(+7)
Cs	55	132.905	0.7	16.3	0.50	0.053	—	0.052	90	2.25	1.69(+1)	70	2.67
Ba	56	137.34	0.9	35.7	1.83	0.016	—	0.068	120	1.98	1.35(+2)	39	2.22
La★	57	138.91	1.1	96	1.5	0.017	0.033	0.045	129	1.69	1.15(+3)	22.5	—
Hf	72	178.49	1.3	155	5.2	0.031	0.22	0.035	127	—	0.81(+4)	13.6	—
Ta	73	180.948	1.5	180*	6.8	0.081	0.13	0.036	138	1.46	0.73(+5)	10.9	—
W	74	183.85	1.7	185	8.05	0.181	0.40	0.032	184	1.39	0.64(+4)	9.53	0.68(+6)
Re	75	186.207	1.9	152	7.9	0.051	0.17	0.033	182	1.37	—	8.85	—
Os	76	190.2	2.2	162	6.4	0.11	—	0.031	201	1.35	0.67(+4)	8.43	—
Ir	77	192.22	2.2	152	6.6	0.189	0.14	0.031	212	1.36	0.66(+4)	8.54	—
Pt	78	195.09	2.2	122	5.2	0.095	0.17	0.032	207	1.38	0.52(+2)	9.10	—
Au	79	196.967	2.4	81.8	3.03	0.42	0.71	0.031	213	1.50	1.44	10.2	1.37(+1)
Hg	80	200.59	1.9	13.9	0.56	0.011	0.02	0.033	241	1.49	1.57	14.8	1.10(+2)
Tl	81	204.37	1.8	38.8	1.02	0.055	0.093	0.031	141	1.48	1.71	17.2	0.95(+3)
Pb	82	207.19	1.8	42.4	1.22	0.046	0.083	0.031	171	1.47	1.75	18.3	1.20(+2)
Bi	83	208.980	1.9	42.7	2.6	0.009	0.02	0.034	185	1.46	1.70	21.3	0.74(+3)
Po	84	(209)	2.0	29	—	0.02	—	—	—	—	1.76	22.7	—
At	85	(210)	2.2	8	—	—	—	—	—	—	—	—	—
Rn	86	(222)	—	3.92	0.69	—	—	—	248	2.14	—	—	—
Fr	87	(223)	0.7	—	0.9	27.4	2.4	—	—	1.1	—	—	—
Ra	88	(226)	—	1.40(+2)	—	—	45	—	—	—	—	—	—
Ac★★	89	(227)	—	1.18(+3)	—	—	—	—	—	—	—	—	—
Ce★	58	140.12	1.1	95	1.2	0.013	0.026	0.042	159	1.65	1.01(+4)	21.0	—
Pr	59	140.907	1.1	79	1.60	0.015	0.028	0.048	133	1.65	1.09(+3)	20.8	0.92(+4)
Nd	60	144.24	1.2	69	1.70	0.013	0.031	0.045	133	1.64	1.08(+3)	20.6	—
Pm	61	(145)	—	—	—	—	—	—	—	—	1.06(+3)	—	—
Sm	62	150.35	1.2	46	2.1	0.011	—	0.042	129	1.66	1.04(+3)	19.9	—
Eu	63	151.96	—	42	2.2	0.012	—	0.039	131	1.85	1.12(+2)	28.9	—
Gd	64	157.25	1.1	72	3.70	0.007	0.021	0.071	142	1.61	1.02(+3)	19.9	—
Tb	65	158.924	1.2	70	3.9	0.009	—	0.044	155	1.59	1.00(+3)	19.2	—
Dy	66	162.50	—	67	4.1	0.011	0.024	0.041	157	1.59	0.99(+3)	19.0	—
Ho	67	164.930	1.2	67	4.1	0.011	—	0.039	155	1.58	0.97(+3)	18.7	—
Er	68	167.26	1.2	67	4.1	0.012	0.023	0.040	—	1.57	0.96(+3)	18.4	—
Tm	69	168.934	1.2	59	4.4	0.011	—	0.038	—	1.56	0.95(+3)	18.1	—
Yb	70	173.04	1.1	38	1.8	0.035	—	0.035	143	1.70	1.13(+3)	24.8	0.94(+2)
Lu	71	174.97	1.2	90	4.6	0.015	—	0.037	115	1.56	0.93(+3)	17.8	—
Th★★	90	232.038	1.3	—	4.6	0.055	—	0.034	—	1.65	1.14(+3)	19.9	—
Pa	91	(231)	—	130	—	—	—	—	—	—	1.12(+3)	15.0	—
U	92	238.03	1.5	110	2.7	.034	0.064	0.028	—	1.42	1.11(+3)	12.5	0.89(+4)
NP	93	(237)	1.7	—	—	—	—	—	—	—	1.09(+3)	21.1	0.88(+4)
Pu	94	(244)	1.3	—	—	—	—	—	—	—	1.07(+3)	—	0.86(+4)
Am	95	(243)	—	—	—	—	—	—	—	—	1.06(+3)	20.8	0.85(+4)
Cm	96	(247)	—	—	—	—	—	—	—	—	—	—	—
Bk	97	(249)	—	—	—	—	—	—	—	—	—	—	—
Cf	98	(251)	—	—	—	—	—	—	—	—	—	—	—
Es	99	(254)	—	—	—	—	—	—	—	—	—	—	—
Fm	100	(257)	—	—	—	—	—	—	—	—	—	—	—
Md	101	(258)	—	—	—	—	—	—	—	—	—	—	—
No	102	(259)	—	—	—	—	—	—	—	—	—	—	—
(Lw)	103	(262)	—	—	—	—	—	—	—	—	—	—	—

See note 3

KEY

Zn — Symbol; Atomic Number; Atomic Weight; Electronegativity (Pauling's); Heat of Vaporization (kg-cal/g-atom) (*,5); Heat of Fusion (kg-cal/g-atom); Electrical Conductance (6) (microhms)*1; Thermal Conductance; Specific Heat (cal/g/°c); First Ionization Energy (kcal/g-mole); Covalent Radius, Å; Ionic Radius, Å (7); Atomic Radius, Å (8); Atomic Volume, W/D; Crystal Structure (2); Acid-Base Properties (1)

NOTES: * Element sublimes

(1) For representative oxides (higher valence) of group. Oxide is acidic if color is red, basic if color is blue and amphoteric if both colors are shown. Intensity of color indicates relative strength.

(2) Cubic, face centered; cubic, body centered; diamond; cubic; hexagonal; rhombohedral; tetragonal; orthorhombic; monoclinic.

(3) Proposed; not officially accepted (4) At room temperature. (5) At boiling point.

(6) From 0° to 20°C. (7) Ionic (crystal) radii for coordination number 6.

SARGENT
E.H. SARGENT & CO. SCIENTIFIC LABORATORY EQUIPMENT
CHICAGO DETROIT DALLAS BIRMINGHAM SPRINGFIELD, N.J. ANAHEIM, CALIF.

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from abstract ideas . . . fundamental knowledge at Esso Research

Distribution of surface energies of catalysts can be altered to a considerable degree, it has been determined by Victor Kevorkian, an Esso Research scientist using microcalorimetry. The differential microcalorimeter being used is a sensitive tool which measures adsorbate-adsorbent and adsorbate-adsorbate interactions, as a function of surface coverage.

At low surface coverages, the heat of adsorption of NH_3 on aluminum oxide is quite high and falls gradually with increasing coverage to values expected for physical adsorption. This indicates strong acidity at some surface sites and also marked heterogeneity of the surface. The heat-coverage curve may also go through a minimum, giving information about interactions among adsorbed species. In contrast with Al_2O_3, silica adsorbs NH_3 only weakly and its surface is a homogeneous one. The presence of trace alkali metal or the preadsorption of molecules such as H_2O which can compete for acidic surface sites has a large effect on surface energy distribution. Thermal treatment of aluminum oxide before NH_3 adsorption greatly changes its surface properties. These measurements are therefore giving important information about catalytic surfaces and the degree to which surface properties can be altered or controlled.

With the installation of new equipment, the measurements are being extended to the region of 1000°F., where among other studies, the adsorption of at least the stable hydrocarbons will also be investigated.

Some progress has also been made in an attempt to relate the measured surface energy distributions to kinetics of different elementary reactions — for example, the carbonium ion rearrangement of butene-1 to butene-2. If such investigations are successful, it should eventually be possible to alter in a controlled way the distribution of surface sites to promote specific desirable reactions and minimize others.

. . . adapted from the scientists' notes at
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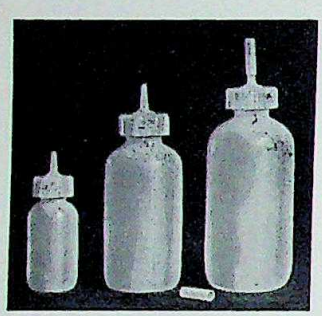

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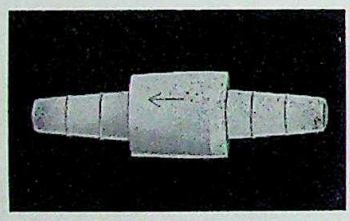

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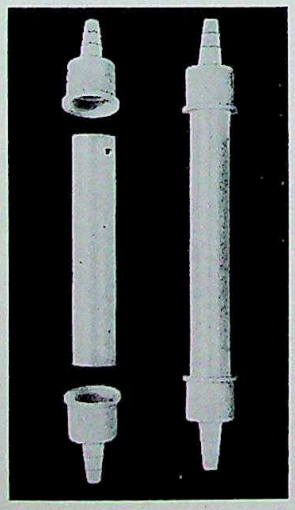

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Out of the EDITOR'S BASKET

◇ Gallard-Schlesinger Chemical Mfg. Corp., 1001 Fraulclin Ave., Garden City, Long Island, New York offers a new bulletin "Materials for Gas Chromatography."

Miscellany

★ Do you ever wonder about the number and variety of scientific and engineering societies and their real contributions to our society? F. L. LaQue's article "Technical Societies and Their Contributions to Industry" in Volume 28, No. 7 of the Inco Magazine identifies these benefits. Especially pertinent to the chemistry instructor is this paragraph: "Through their publications of papers, books, manuals, monographs, recommended practices, testing methods, specifications, and standards, they record the accumulated knowledge and experience that form the basis upon which all advances in science and technology are achieved. This record of scientific findings is essential, too, in the education of the students who must be relied upon to maintain and advance a civilization that has become more and more dependent on science and engineering."

★ Modern Learning Aids, 3 E. 54th St., New York 22, N. Y. offers a folder describing 19 films now available, that were prepared as part of the Chemical Study course in Chemistry.

★ Establishment of a research award that provides as much as $25,000 to an individual has been announced by Olin Mathieson Chemical Corp. As many as three such awards can be made in any single year for exceptional achievement by Olin personnel, according to Dr. W. E. Hanford, Vice President.

★ A Raman Seminar-Workshop will be held by Applied Physics Corp., at the Company's offices and plant in Monrovia, California, on October 7–11, 1963. The program, successfully initiated last fall, will include lectures on Raman theory, applications, instrumentation, and correlation with infrared spectroscopy. Those interested in the program should contact David C. Nelson, Applications Development Dept., Applied Physics Corp., 2724 South Peck Rd., Monrovia, California.

★ The Chemical Division of the American Society for Quality Control will hold its Seventh Annual Technical Conference in St. Paul, Minnesota on November 7–8, 1963. Papers will be presented on the design and analysis of experiments, acceptance sampling, process control, operations research and related topics. Features of the program will include a talk by Mr. H. P. Buetow, President of Minnesota Mining and Manufacturing Co., and the celebration of the tenth anniversary of the Chemical Division. Further information may be obtained from Bruce A. Drew, The Pillsbury Co., 311 2nd St. SE, Minneapolis 14, Minn.

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What does Olin make?
What are the types of work at Olin?
What are the opportunities at Olin?

Who is Olin? Olin is a worldwide company with 39,000 employees developing, producing and marketing products from seven divisions: Packaging, Squibb, Winchester-Western, Chemicals, International, Metals and Organics. With corporate offices in New York City, the firm operates 56 plants in 30 states with plants and affiliates in 37 foreign countries.

What does Olin make? Major brand names include Squibb, Winchester-Western,® Waylite,® Ramset,® Roll-Bond,® with fully integrated product lines in industrial and agricultural chemicals, medicinals and pharmaceuticals, arms and ammunition, brass and aluminum, fine papers and transparent films, kraft papers, multi-wall bags and containers.

What are the types of work at Olin? Olin's great diversity provides a broad range of opportunities in the technical science and engineering fields. Emphasis is placed on the B.S. and M.S. chemical, industrial, mechanical and metallurgical engineering student for assignments in plant operations, process control, product development, quality control, production and marketing. Advanced degree M.S. and Ph.D. chemists and metallurgists work in central research and development improving existing products and developing new ones. Men with liberal arts and business backgrounds find rewarding career opportunities in the administrative functions, marketing, and some areas of manufacturing.

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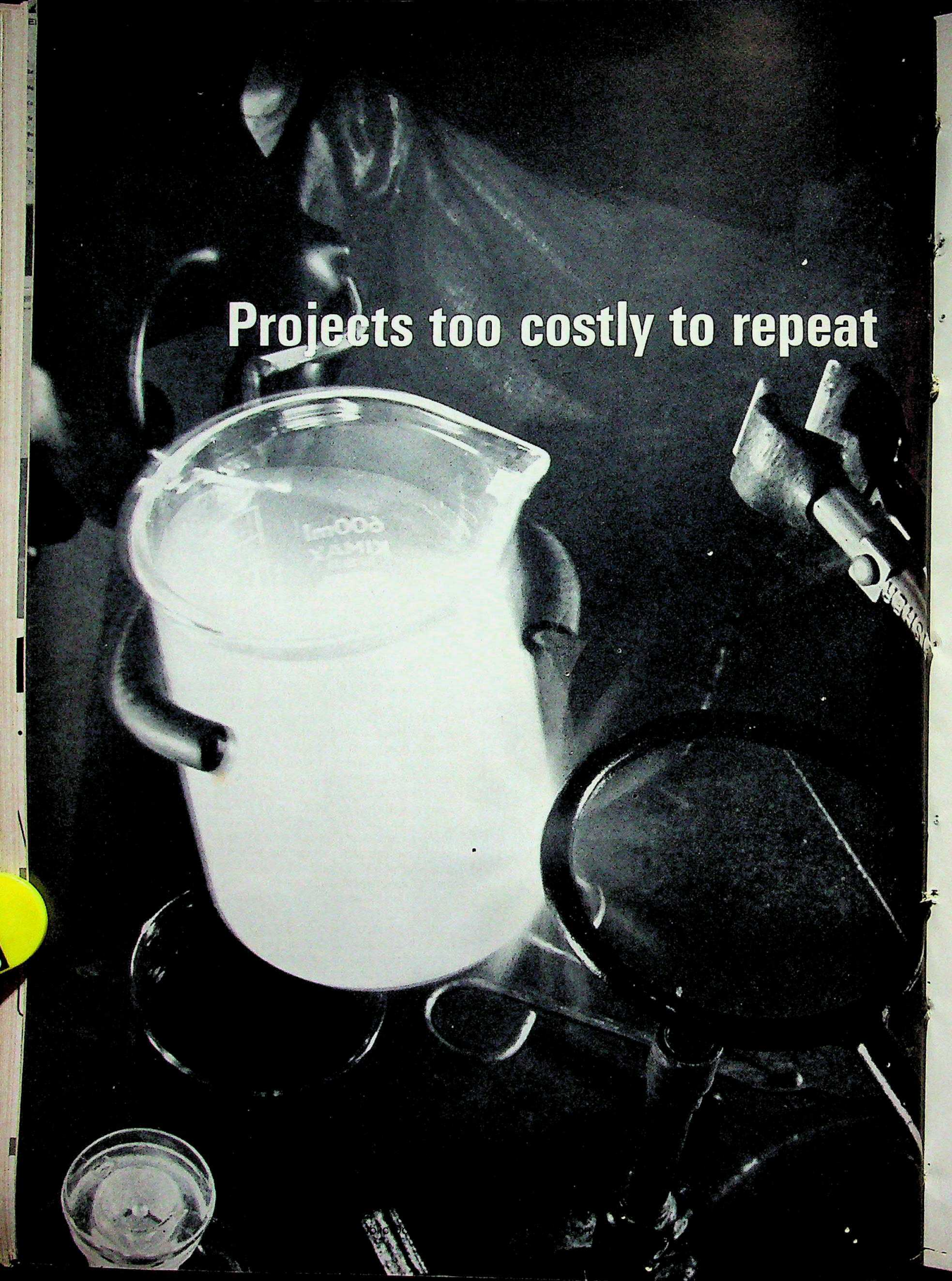
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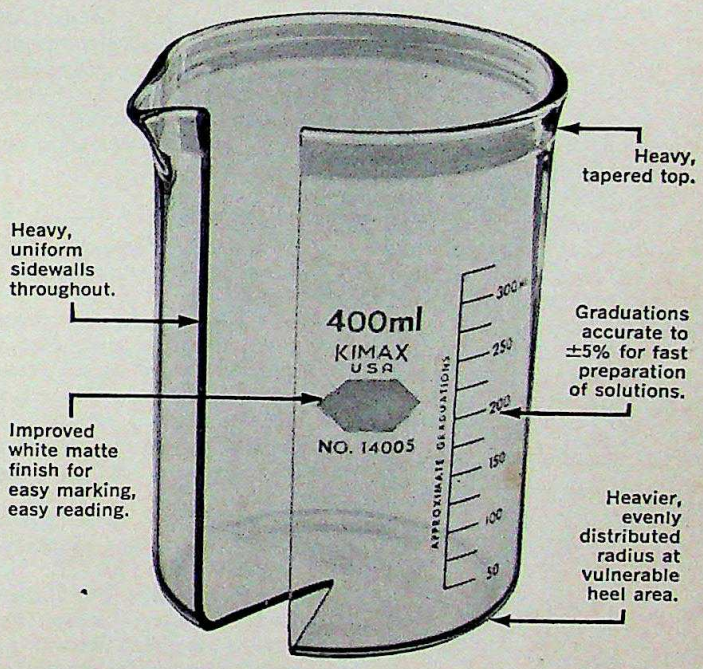

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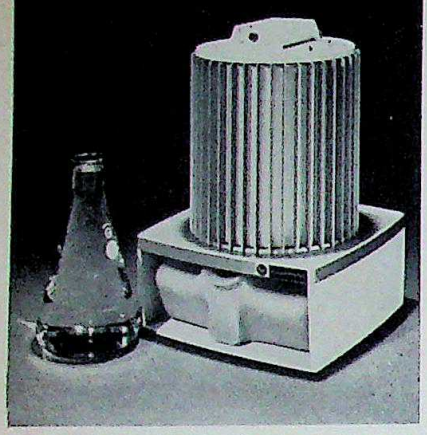

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Out of the EDITOR'S BASKET

★ The Weizmann Institute of Science, Isotope Department—Heavy Oxygen Plant, announces that high enrichments of both stable isotopes of oxygen have recently been achieved. Up to 99 atom % Oxygen-18 has been available for some time in various chemical forms and has already been widely used in chemistry and biology as a tracer and as both target and projectile in nuclear studies. Oxygen-18 labeled compounds also have great potentialities in studies of isotope effects and spectral isotopic shifts.

Oxygen-17 with a spin of 5/2 is the only isotope of oxygen which can be used for NMR and ESR studies. Enrichments of over 10 atm % O^{17} in oxygen gas have recently been reached on a production scale in the Isotope Separation Plant of the Weizmann Institute of Science. These concentrations represent a 250 fold enrichment of O^{17} in water and 1350 fold enrichment in oxygen gas.

These materials are now available through YEDA Research and Development Co., Rehovoth, Israel. An informative pamphlet has been prepared which contains pertinent references and a catalogue of O^{18}- and O^{17}-enriched materials at newly reduced prices.

Copies of this booklet are available on request.

★ The Fifteenth Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, sponsored by the Analytical Chemistry Group of the Pittsburgh Section of the American Chemical Society and the Spectroscopy Society of Pittsburgh, will be held at the Penn-Sheraton Hotel in Pittsburgh, Pennsylvania, from March 2 to March 6, 1964.

Original papers on all phases of analytical chemistry and spectroscopy are invited.

Correspondence regarding papers should be submitted before October 15, 1963, in duplicate to: Mr. R. B. Fricioni, Program Chairman, The Pittsburgh Conference, Allegheny Ludlum Steel Corp., Corporate Quality Control Laboratory, Research Center, Brackenridge, Pennsylvania.

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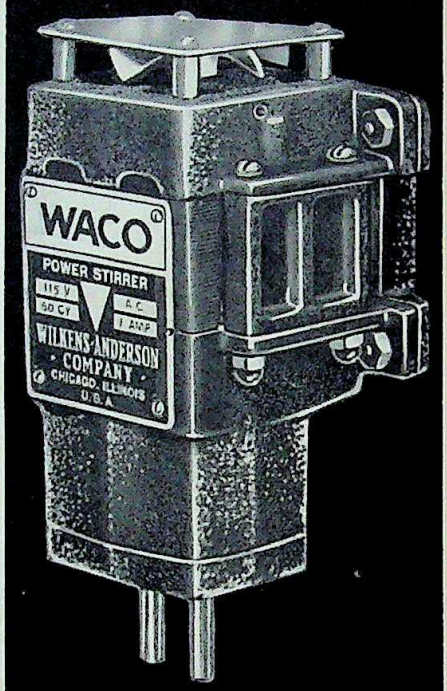

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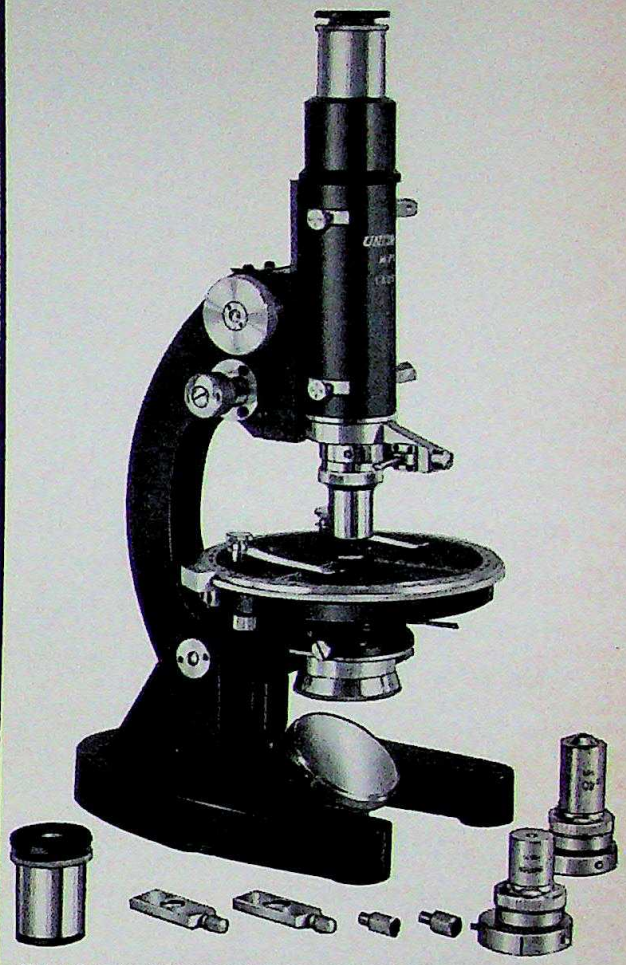
Here is a precision measuring instrument for both orthoscopic and conoscopic observations, designed to meet the exacting requirements of science, education, and industry. Its many features make it ideal for work in chemistry, crystallography, mineralogy and biology as well as in the technology of paper, glass, textiles and petroleum.

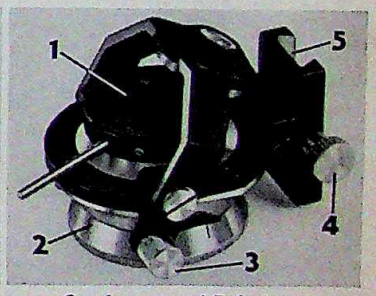
CHECK THESE OPTICAL & MECHANICAL FEATURES

Note that UNITRON'S new Model MPS comes complete with optics and accessories and includes features usually associated only with much more costly models.

- **EYEPIECES:** Micro 5X providing measurements to 0.0025mm. and cross-hair 10X. The eye lenses focus to produce sharp reticle images and are keyed to prevent rotation.
- **OBJECTIVES:** 4X(N.A.0.1), 10X(N.A.0.25), 40X(N.A.0.65), achromatic, strain-free, each with centerable mount.
- **NOSEPIECE:** quick-change type for critical centering.
- **CONDENSER and POLARIZER:** three-lens condenser with upper elements on a swing-out mounting, provides either parallel or convergent light. A dovetail-slide focusing mount and iris diaphragm insure optimum illumination and resolution.
- **POLAROID POLARIZER:** rotatable through 360° and graduated every 45°. Plano-concave mirror.
- **ANALYZER:** Polaroid, in sliding metal mount.
- **BERTRAND LENS:** for the study of interference figures, fixed-focus lens is centerable and mounted in a slideway.
- **STAGE:** diameter 115mm., revolves through 360°, graduated in degrees and reads to 6′ with vernier. The top is calibrated in mms. in two directions and is drilled and tapped for an accessory mechanical stage. Stage clips.
- **COMPENSATORS:** two compensators are included; a quarter-wave plate and first order red plate. These fit into a slot above the objective lens.
- **FOCUSING:** coarse and micrometric fine adjustments.
- **STAND:** heavy stand, arm inclines to horizontal position.



1 Iris diaphragm
2 Polarizer
3 Swing-out lever
4 Focusing lock
5 Focusing slide



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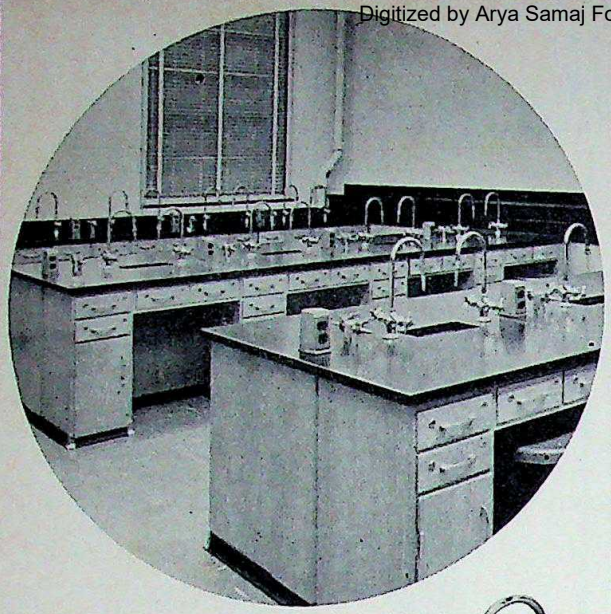

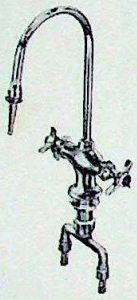

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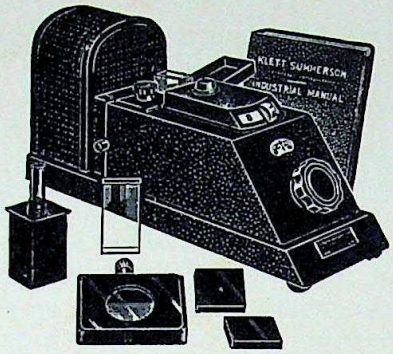

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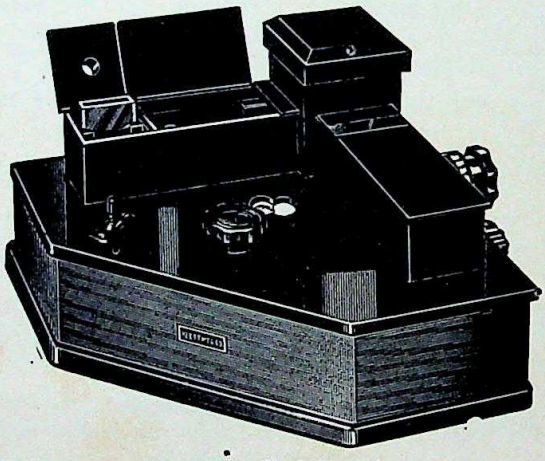
The Klett Fluorimeter



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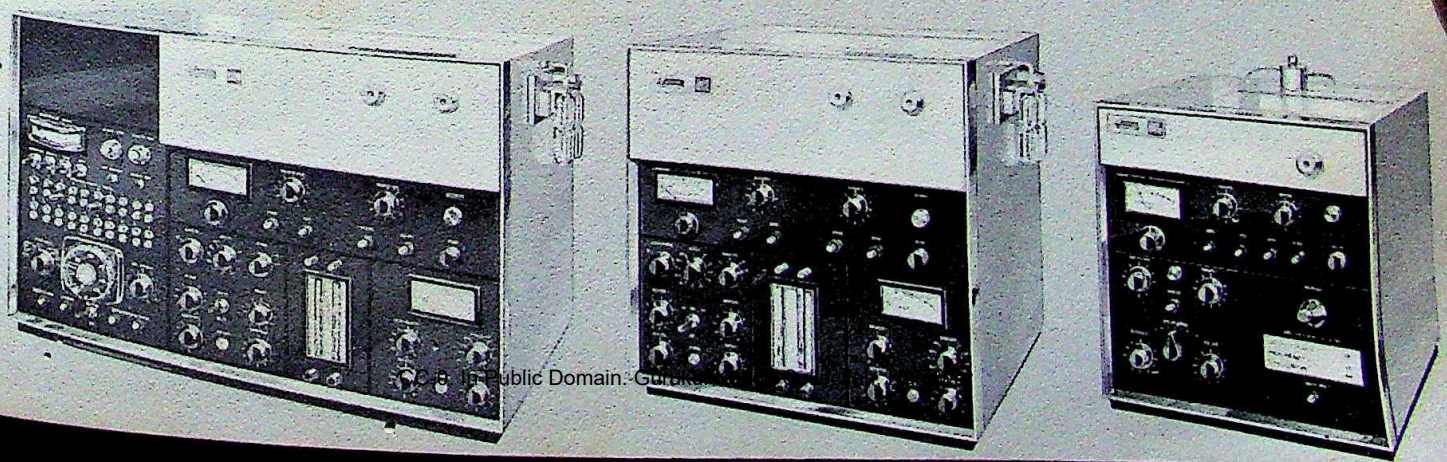
moduline

a new Aerograph series featuring the HY-FI2

The 1520

The 202

The HY-FI2



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Moduline series

How can you design a gas chromatograph and protect heat-sensitive electronic components from the oven heat? One cumbersome method is to build two separate units.

The new Aerograph Moduline series accomplishes this in a trim, beautiful, single-unit manner. A through-shaft motor drives two fans. One fan circulates column oven air, while the other draws in cool air from the outside and efficiently keeps the electronic components cool.

Three sparkling new basic models were developed in a truly modular concept.

The Hy-Fl_2, a big brother to the popular Hy-Fl 600-C, is a single-column instrument which adapts perfectly to all of the following detectors: Flame, Electron Capture, Cross-section (available Jan. 1964), Thermal Conductivity, and Flame-Electron Capture combination. Manual or linear temperature programming modules are optional.

The "202"* is a two-column instrument adaptable to both Dual Flame and Thermal Conductivity detectors. Manual or linear temperature programming modules are optional.

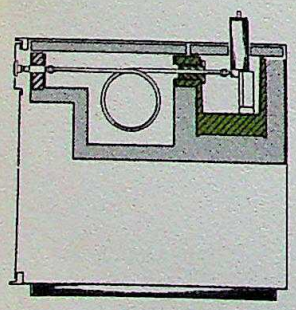
The "1520"* is a deluxe version of the 202 equipped with both Dual Flame and T.C. detectors. It features matrix board temperature programming, automatic cooldown, and automatic reset-to-start temperature.

*For more information, please see page 4.

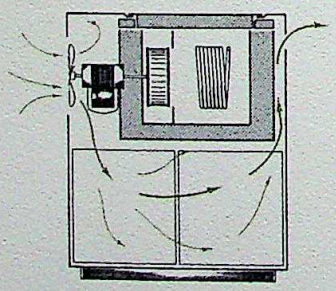
Hy-Fl_2 features

- The basic design of the $HyFl_2$ permits easy interchange of the three basic ionization detectors, all used with the standard single-channel electrometer.
- The Hy-Fl_2 may also be used with the standard 4-filament thermal conductivity detector cell by interchanging the electrometer with a bridge-power supply module.
- A most interesting and useful combination incorporates both flame and electron capture detectors used with the special two-channel electrometer shown in picture opposite. With this combination the column effluent is divided by a stream splitter to feed both detectors. The signals from both detectors are amplified by the two-channel electrometer which in turn operates a two-pen recorder. A standard peppermint oil sample was analyzed using this unique instrument, and the startling two-pen trace is shown on page 4.
- The temperature of the $HyFl_2$ column oven is controlled by two methods: Standard, with manual temperature programmer module incorporating a constant voltage, solid-state electronic controller. Deluxe, with an all-electronic linear temperature programming module.
- The cast aluminum separate detector oven is controlled at four set temperatures also using the constant voltage, solid-state electronic conroller.

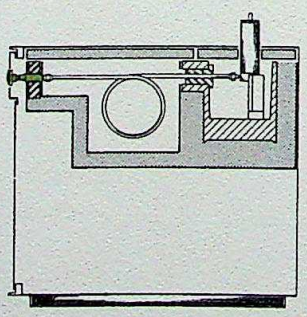
Plan to see the Hy-Fl_2, the 202, and the 1520, at the Fall ACS meeting, New York Hilton Hotel, N.Y.C. Booth 801.



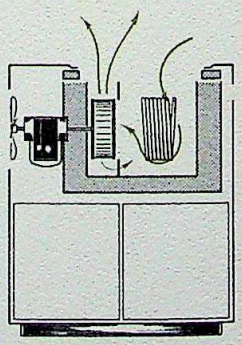
Separate Detector Oven —The temperature of this heavy cast aluminum oven, heated by a 250 watt ring heater, is regulated by a unique solid-state, constant power, electronic controller.



Air-Cooled Cabinet — A 4-blade fan, circulating air at the rate of 70 cubic feet per minute, effectively cools all electronic components. The cabinet temperature is less than 40°C.



Two-Inch Injector — On-column injection is an important aspect in GC. The 2" injector, standard on all Moduline instruments, permits on-column injection with standard Hamilton syringe.



Rapid Oven Cooling — When the column oven door is opened, hot air is exhausted at approximately 200 cubic feet per minute which will cool the column from 400° to 100°C in 4 minutes.

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The Hy-Fl$_2$

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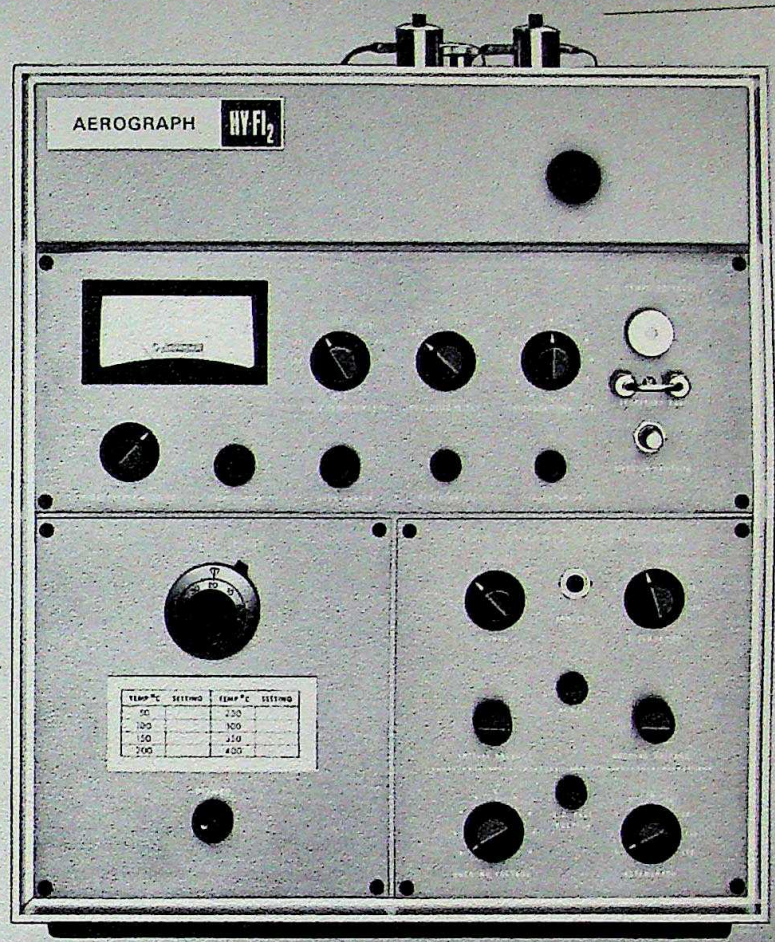
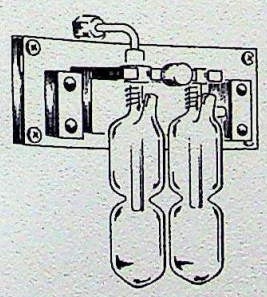
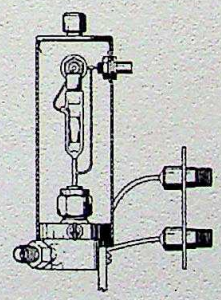
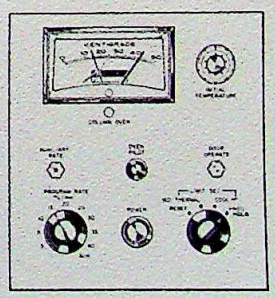




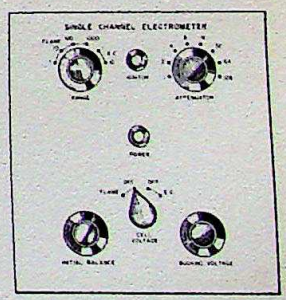
Two-Position Collector—This manual collector, which supports two Autoprep collector bottles, is standard with any Moduline instrument equipped with thermal conductivity detectors.



Detectors—Five options are available: 1. Flame; 2. Electron Capture; 3. Cross-Section; 4. Thermal Conductivity; 5. Flame-Electron Capture combination. Interchangeable in the Hy-Fl$_2$.



Linear Temperature Programmer — This programmer is completely electronic with no gears, motor or clutch. It programs at 10 precise rates. A jack plug permits any additonal rates.



Bridge-Power Supply — This 12 or 20 volt solid-state bridge and power supply module is used in conjunction with 4 - filament T.C. detectors. It is interchangeable in the Hy-Fl$_2$, 202 or 1520.

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Moduline models

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HY-FI2

202

1520

AEROGRAPH

The Module Concept

A true modular design permits the option to use and interchange functional components. This minimizes manufacturing problems and increases versatility to the user. The chemist, in this instance, can order precisely the instrument of choice or he can alter the functionality at a later date by interchanging modules.

The Hy-FI_2, a single-column instrument, can be used with any of the four common detectors or as a combination instrument with flame plus electron capture. Either a manual or a linear temperature programming module may be selected.

The 202, a dual-column instrument can be used with either two flame or thermal conductivity detectors. Again, manual or linear programming is optional. Dual flow controllers, flow meters, and automatic door opener are standard.

The 1520 is like the 202 except it has both dual flame and thermal conductivity detectors. The all-electronic matrix board temperature programmer, standard, not only gives complete flexibility in pre-setting program rates, but automatically closes the oven door after cool-down and re-sets the start temperature.

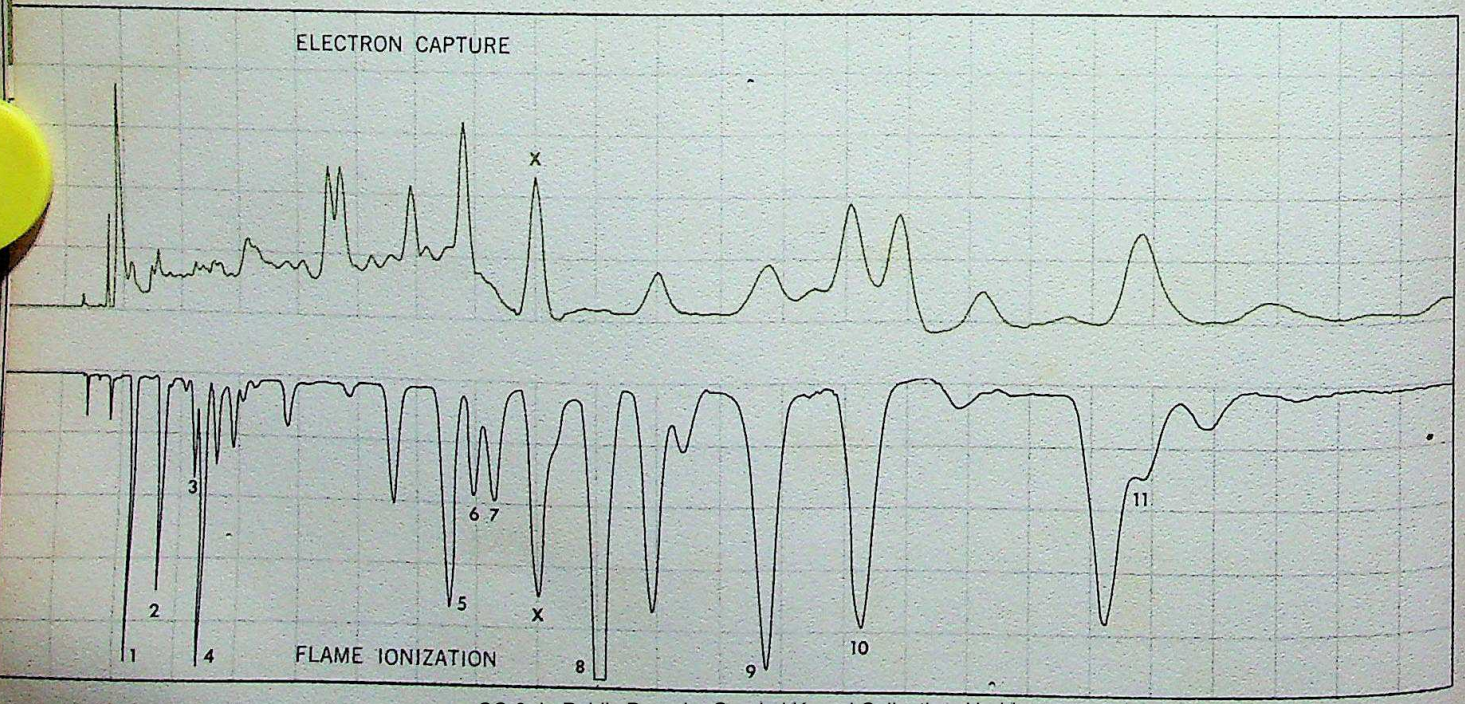
HY-FI_2 Dual-Channel

Dual-channel gas chromatography is very analogous to stereo music. The response of the record (equivalent to the gas chromatograph column) is separated and picked up by two heads (equivalent to the Flame and E.C. detectors). Signals from each head are separately amplified (dual electrometer) and fed to two speakers (the twin pen recorder).

The Flame and E.C. combination seems particularly ideal since the E.C. detector is sensitive to only a few types of molecules as halides, conjugated carbonyls, nitro compounds and certain sulfur-containing compounds.

The E.C. peaks shown in the peppermint trace below were not identified. The one marked "X," an added marker, is benzaldehyde which was known to give about equal response on both detectors. Menthol was the only other component which recorded simultaneous peaks. In short, the E.C. trace shows an entirely new pattern for peppermint oil. These components may be most vital to the natural flavor.

Conditions: $HyFI_2$ two-channel; Column, 20′ x ⅛″, 5% Carbowax, 20 M; 143°C. Sample, peppermint oil 0.15 μl • split 1.2:1 FL/EC ■ 1-α Pinene • 2-β Pinene 3-Limonene • 4-Eucalyptol • 5-Menthone • 6-Menthofuran • 7-Isomenthone • X-Benzaldehyde • 8-Menthyl Acetate • 9-Menthol • 10-Pulegone • 11-Piperitone



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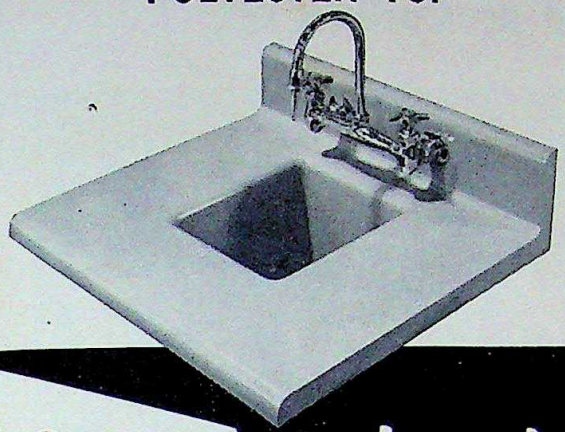

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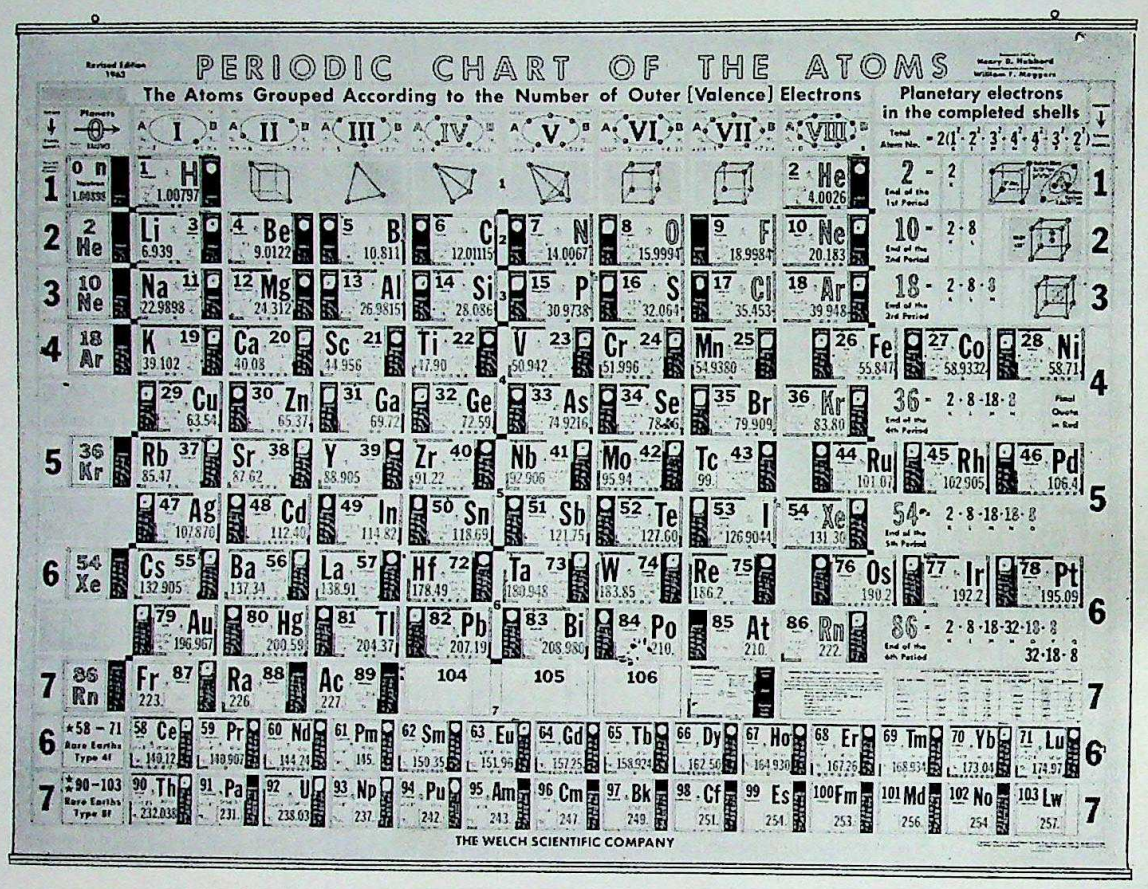

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Chem Ed

EDITORIALLY SPEAKING

September means a new start for most persons whose lives are in any way related to the academic community. Even the professor whose name has been on a course label for decades approaches the opening of a new term with reconsideration. What can he say to reveal his own enthusiasm and hopefully to kindle some in his students? A cynic's view is that the opening lecture is the one that means most to the professor and least to the student. This may be disconcertingly true at the time, but seldom is it a valid commentary at the end of a well taught course. The initial lecture should set the stage. The student should know what the professor thinks "it is all about!"

Favorite themes for the first class meeting are definition, scope, point of view, or philosophy of science. This is important and the thoughtful student deserves it. However, the professor misses his chance to excite an inquiring mind if ludicrous oversimplifications are delivered in a pontifical manner. "The chemist seeks truth by employing the scientific method," for example!

George Gaylord Simpson, Agassiz Professor at Harvard, has written a most stimulating essay in the Harcourt, Brace & World pamphlet, "Notes on the Nature of Science." (Copyright 1961, 1962) In defiance of our own warning about oversimplification, we would like to quote what should provide provocative themes on which professors may build their own variations.

Attempts at definitions of science have varied from T. H. Huxley's "common sense . . . the necessary mode of working of the human mind" to Norman Campbell's "study of those judgments concerning which universal agreement can be obtained." On the face of them and without such qualifications as their authors did indeed provide, those definitions can lead to absurdities. Everyone knows that so-called common sense and the working of the human mind have produced an intolerable amount of nonsense, and that above the level of triviality there is hardly any scientific subject on which agreement is literally universal.

Those two inadequate definitions are nevertheless related to the two most important aspects of the scientific attitude. Science is an exploration of the material universe that is, first, orderly and, second, self-testing. This statement is also inadequate and requires some expansion.

The orderliness of science consists in seeking regularities—rationally definable relationships—among the enormously diverse phenomena of the world we live in . . . On the more workaday level of the teaching and the practice of science, an important point is that isolated facts—call them "data" if you like—are meaningless. It is only their generalization and their ordering into principles that give them meaning.

The development of an organized system of (real or supposed) relationships among phenomena is necessary but not sufficient for a definition of science; it is not confined to science.

The important distinction between science and those other systematizations is that science is self-testing and self-correcting. The testing and correcting are done by means of observations that can be repeated with essentially the same results by normal persons operating by the same methods and with the same approach. That is the sense in which "universal agreement can (in principle) be obtained." . . . What is correctly observed *must* be believed.

The most fundamental reason for disagreement in science is, however, the inherent impossibility of complete certainty. There are here four main factors. First, one fact may disprove a theory and not all facts can be observed; therefore an investigator cannot completely discard the possibility that a discrepant phenomenon may occur. Second, in any complex situation the data are rarely so complete that only one explanation (inferred relationship among the facts) can conceivably be correct. What can actually be established is only a degree of probability. In many instances, indeed, the theories themselves are inherently probabilistic in nature, and that is the third important factor in scientific uncertainty . . . The final factor is that no scientific explanation so far achieved is in the fullest sense of the word *complete*.

The concept of "truth" in science is thus quite special. It implies nothing eternal and absolute but only a high degree of confidence after adequate objective self-testing and self-correction.

Chemistry is *not* an exact science. If it were, we could not paraphrase the epigram by one of the greatest chemists, G. N. Lewis, "The chemist never talks about 'in the last analysis,' rather he is interested in 'the next approximation'." What better first thoughts for chemistry students?

Editorial Office Change of Address

Beginning September 1, 1963 and continuing for the academic year 1963–64, the editorial office of THIS JOURNAL will be in the Department of Chemistry at MIT where the editor will be in residence as an NSF Science Faculty Fellow. All editorial correspondence should be addressed:

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Henry A. Bent
University of Minnesota
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Tangent-Sphere Models of Molecules

I. Theory and construction

Quantum mechanics has achieved some striking successes. Exact calculations have been made of the complex spectroscopic properties of the hydrogen atom and the hydrogen-molecule ion. In addition, computations of extraordinary accuracy have been made of the bond dissociation energy of the hydrogen molecule and of the ionization energy of the helium atom, the latter—with the aid of a 1078-term function—to an accuracy of one part in two billion (*1*). At this level of computational accuracy, relativistic corrections for the variation in mass with velocity and for the spin magnetic dipole interaction between electrons become important.

Equally striking, however, is the loss of accuracy in calculations on more complex systems (*2*). Reminiscent of the time in the development of the Debye-Huckel limiting law for ionic solutions when physical chemistry was sometimes humorously referred to as the chemistry of slightly impure water, rigorous quantum chemistry today might be called in the same spirit, a quantitative theory of the hydrogen molecule, and of slightly less complicated systems.

But as Platt has pointed out (*3*), quantitative calculations on the hydrogen molecule, however exact, yield essentially no information whatsoever regarding stereochemistry. It is not surprising, therefore, to find that rigorous quantum chemistry has so far failed to become a workable, everyday theory of chemical structure. There seem to be at least two possible reasons for this.

First, the calculation of the properties of a many-electron system based upon a straightforward, mathematical solution of the Schrödinger equation is impossible. Hartree has pointed out that merely to print the result of such a calculation for a single stationary state of a single stage of ionization of a single atom as complex as iron would require more matter for ink and paper than is contained in the entire universe (*4*). Clearly such an answer even if computable would be far too bulky to use. Moreover, Dirac has shown that it would contain an enormous amount of superfluous information (*5*). To compute exactly the energy of an N-electron system, for example, the full wave function ψ expressed as a function of the separate coordinates of each electron is not necessary. Wilson has shown that a knowledge of the ordinary 3-space electron density as a function of, say, the nuclear charges is sufficient (*6*). Also hanging over the calculation is the haunting possibility that the entire effort *may be* operationally unsound, in as much as the wave function for a many-electron system is not a physical observable or even very closely related to one.[1] This has led to a situation in which massive efforts have been made to solve by approximate methods a philosophically questionable problem whose solution, if it could be obtained, probably could not be used and, if it could be used, probably would be much more complex than necessary.

The second reason why rigorous quantum chemistry has failed to become a workable and broadly applied theory of structural chemistry concerns a time-honored approximation that is several years older than wave mechanics itself. Except in a small number of highly specialized calculations—mainly those on hydrogen and helium—the wave function of an N-electron atomic or molecular system has always been taken to be a product (or sum of products) of N "one-electron orbitals." But again these are not physically observable and in a many-electron system there is in reality no such thing as a "one-electron orbital." Indeed, the idea of overlapping (albeit orthogonal) "one-electron orbitals" is contrary to the intrinsic character of the Pauli principle. The Pauli principle is essentially a statement concerning the collective particle behavior of a system of electrons, whereas the idea of "one-electron orbitals," to be truly valid in a physical sense, as opposed to being valid or useful in a computational sense, must presume that the system exhibits in an essential manner the characteristics of a collection of independent particles. Both Coulomb forces and the effects of the Pauli principle, however, prevent electrons in atoms and molecules from behaving as independent particles.

In summary, one is struck by several facts. The most highly successful applications of quantum mechanics to chemistry have almost invariably been concerned with the properties of the ground states of very simple one- and two-electron systems (H, H_2^+, H_2, and He); and always in the latter instances to achieve high computational accuracy the idea of one-electron orbitals has been abandoned. Equally significant, perhaps, is

A preliminary account of this work was presented at the Gordon Research Conference in Inorganic Chemistry, New Hampton, N. H., August 6–10, 1962.

This study was supported by a grant of a Faculty Summer Research Appointment from the Graduate School of the University of Minnesota, by a du Pont Grant-in-Aid to the Department of Chemistry of the University of Minnesota, and in part by the National Science Foundation. This support is gratefully acknowledged.

[1] One might consider, for example, how the electron density function ρ is related to ψ. In a simple, one-electron system, ρ is obtained from ψ by simply multiplying ψ by its complex conjugate ψ^*. The product $\psi\psi^*$, times the electronic charge, is the electron density function ρ. To obtain ρ for a many-electron system, one must, in addition, integrate the product $\psi\psi^*$ over the complete range of the electronic coordinates, spatial and spin, of every electron but one.

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the fact that in none of the systems treated with great accuracy are there even two electrons of parallel spin. In a sense, quantum mechanics has not yet treated with the accuracy demanded by chemists the properties of systems for which the Pauli principle may be important. A moral may perhaps be drawn from this. It is that in passing from one- and two-electron systems to complex many-electron systems one should not be surprised if there should emerge in the description of the electron clouds of the complex systems features not previously emphasized in accurate computations on the simpler systems.

The discussion of the electronic structure of molecules that follows will be based upon a direct use of the total electron density distribution in molecules and upon two fundamental principles that presumably govern (or describe) the nature of this distribution: the Pauli principle and the Hellmann-Feynman theorem (*7*) (see also Part II). The Hellmann-Feynman theorem is a consequence of the Schrödinger equation; the Pauli principle is not. The procedure usually adopted in discussions of molecular structure is to begin with the Schrödinger equation and to introduce at some later stage the Pauli principle. It is sometimes convenient, as will be illustrated here, to introduce these two fundamental statements in the opposite order.

Pauli Principle and the Fermi Hole

We seek for the Pauli principle a statement whose validity is not contingent upon the validity of the idea of "one-electron orbitals." Such a statement is the statement that the wave function ψ must be antisymmetric with respect to an interchange in the coordinates of any two electrons. For example, for the interchange of coordinates (spatial and spin) of electrons 1 and 2, the Pauli principle states that

$$\psi(x_1, x_2, x_3, \ldots) = -\psi(x_2, x_1, x_3, \ldots) \qquad (1)$$

In this expression

$$x_i = r_i, \xi_i$$

where r_i represents the spatial coordinates of electron i (say its Cartesian coordinates x_i, y_i, z_i) and ξ_i represents its spin coordinate. A consequence of equation (1) is that the wave function must vanish whenever electrons 1 and 2 have the same coordinates (spatial and spin). For example, if x_1 and x_2 are equal to some common value, x, it follows from (1) that

$$\psi(x, x, x_3, \ldots) = -\psi(x, x, x_3, \ldots)$$

and, hence, that

$$\psi(x, x, x_3, \ldots) = 0 \qquad (2)$$

It should be noted that the Pauli principle does not imply that the wave function vanish when two electrons of opposite spin ($\xi_1 \neq \xi_2$) are at the same place ($r_1 = r_2$) for then $x_1 \neq x_2$.[2] Nor, in fact, does the Schrödinger equation require that ψ vanish when $r_1 = r_2$ even though the electron-electron repulsion term becomes infinite. This matter has been discussed for the hydrogen molecule by James and Coolidge (*8*). Close approach of two electrons to each other is analogous to penetration of a potential barrier by a light particle. In other words, there may exist in configuration space places where the potential energy exceeds the total energy; the momentum is then imaginary and the kinetic energy negative. Nonetheless, coulombic repulsion between electrons does introduce considerable correlation in their motion. In the hydrogen molecule, for example, the average distance between electrons is greater than the internuclear distance.

The statement summarized in equation (2) is sometimes expressed by saying that "two electrons of parallel spin cannot be in the same place at the same time." In a sense this is a stronger statement concerning the nature of electron correlation in molecules than is the usual statement of the exclusion principle in which it is said that electrons with parallel spins cannot occupy the same orbital. For many orthogonal orbitals—the hydrogen-like $2s$ and $2p$ orbitals, for example, or the usual σ and π components of a multiple bond—overlap extensively in space. Of course, any properly antisymmetrized product function will satisfy equation (2); however, it is important to realize, as has been emphasized in THIS JOURNAL by Kimball and Loebl (*9*), that the mathematical procedure of rendering antisymmetric a product of one-electron orbitals destroys the simple orbital picture one might have started with whenever the starting one-electron orbitals overlap in space. If the physical basis of the orbital picture is to be retained at all, equation (2) suggests that the orbitals used ought to be localized, nonoverlapping orbitals.

The physical significance of equation (2) is illustrated schematically in Figure 1. Such a figure was suggested first in 1933 by Wigner and Seitz in a discussion of the electronic structure of metallic sodium (*10*). The area cross-hatched represents the electron cloud of a many-electron system. The small circle represents the location of a specific electron within whose near-neighborhood the probability of finding another electron of the same spin is very small. In effect about each electron of a given spin exists an excluded volume or, as a Slater has called it, a "Fermi hole" that consists of a deficiency of charge of the same spin as the electron in question (*11*).

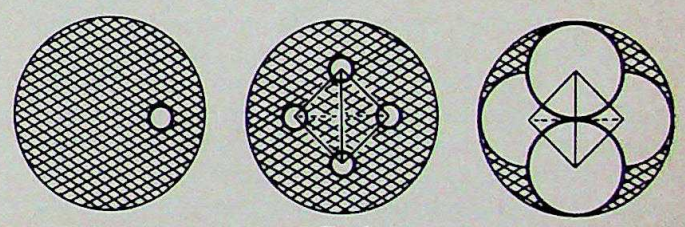

Fig. 1 Fig. 2 Fig. 3

Figure 1. The Fermi hole, after Wigner and Seitz (*10*).
Figure 2. Configuration of maximum probability for four spin-paired valence-shell electrons, according to the Pauli principle (*13, 14*). The atomic nucleus is located at the center of the tetrahedron.
Figure 3. Tangent-sphere model of the electron cloud about an atomic core that is surrounded by four localized electron pairs.

Of considerable chemical interest is the question: How large are these Fermi holes?

The Tangent-Sphere Model

Consider the molecule CH_4. In the carbon atom's valence shell are four electrons whose spins are parallel to each other. Taken in pairs or otherwise these

[2] In the nucleus of an atom, the Pauli principle would permit two protons of opposite spin and two neutrons of opposite spin to share the same region of space.

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electrons can never be in the same place at the same time (equation (2)). In other words, taken together the four electrons constitute in effect a collection of hard objects in the Aristotelian sense (*12*). Would it not therefore be physically reasonable to represent each electron of the collection not as a point particle as one does in setting up the Schrödinger equation but as a sphere whose nonvanishing radius represents the effective chemical radius of the Fermi hole of the electron? If this suggestion is adopted, one is led again to the previous question: In effect, how much of the valence shell is occupied by these Fermi holes?

In seeking an answer to this question, it is convenient to designate as the free volume the volume of the valence shell not occupied by the Fermi holes. Broadly speaking there are three possibilities to consider: the sum of the Fermi volumes may be very much less than the free volume; the sum of the Fermi volumes may be comparable to the free volume; or the sum of the Fermi volumes may be greater than the free volume.

The first possibility corresponds to picturing the mutual behavior of the valence electrons, at least so far as Pauli effects are concerned, as corresponding to that of a collection of almost-independent particles analogous to a dilute van der Waals gas. In these terms the second possibility corresponds to a compressed van der Waals gas and the third possibility to a condensed van der Waals gas.

The third possibility perhaps appears the least credible of the three. In fact, it turns out to be a very useful model of molecular structure. This novel and at first glance seemingly implausible fact can be rationalized—to some extent[3]—in the following manner.

Consider again the four electrons of parallel spin in the valence shell of the carbon atom of methane and suppose that in the space occupied by these four electrons we wish to draw four spheres such that the probability of finding at least one but no more than one electron in each of the four spheres is a maximum. We wish, that is, to draw four spheres such that the product $P_1P_2P_3P_4$ is a maximum, where P_1 is the probability of finding one and only one electron of a given spin in the first sphere, P_2 is the probability of finding one and only one electron of the same spin in the second sphere, etc. Two questions immediately arise.

First: *Where should the sphere centers be placed?* Theoretical calculations based upon the Pauli principle (*13*) and chemical evidence (*14*) suggest the same answer: At the corners of a regular tetrahedron, Figure 2. While it is true that charge correlation would favor the same configuration, the point to be emphasized here is that it may not be necessary (or correct) to invoke coulombic repulsions between electrons in order to explain this tetrahedral arrangement.[4] The Pauli principle by itself tends to make this configuration the most probable one.

The second question is this: *How large should the spheres be?* Make them very small and the probability of finding *even one* electron in the entire set will be very small. On the other hand the probability of finding in a very large sphere *only one* electron is also very small. Clearly there must exist some optimum size for the spheres (*15*). Probably this size will be such that the spheres do not overlap significantly. They could be tangent to each other, however. We assume they are, Figure 3.

In this way we arrive at the tangent-sphere model. In this model the electron pairs in the valence shell of a combined atom are represented (in general) as tangent spheres. The one chemist who seems seriously to have considered this model previously is George Kimball, who with several students has carried through calculations on the hydrides of the second-row elements (*16*). A brief account of their work has been given by Platt (*17*). The energetics of the model have been discussed in a lecture by Kimball (*18*) and in a succinct and lucid statement in THIS JOURNAL by Strong (*19*).[5]

Construction

A model of the tangent-sphere representation of the electron cloud of a methane molecule is easily made by first gluing together three identical spheres, Figure 4 (convenient for personal use are cork balls about $^1/_2$ in. diameter); then add directly above the hole in this trigonal set a fourth sphere (this procedure is indicated in Figure 4 by the "+" sign). This forms a tetrahedron (*cf.* Fig. 3). The four spheres of the tetrahedron

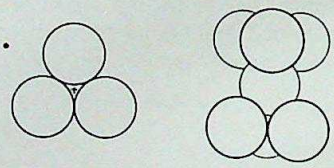

Fig. 4 Fig. 5

Figure 4. Construction of the tangent-sphere model of methane. The "+" signifies the presence in the completed model of a tangent sphere directly above the trigonal hole.

Figure 5. Tangent-sphere model of ethane. The seven spheres shown correspond to the seven lines in the conventional valence-bond structure of ethane. The model includes two tetrahedral holes. These contain the carbon nuclei and their inner-shell electrons. The single sphere between the upper and lower trigonal sets is common to both carbon-core-containing tetrahedral holes. This sphere represents the electron pair of the carbon-carbon bond. For convenience the carbon-carbon and carbon-hydrogen spheres are drawn the same size.

represent the four electron pairs of the C—H bonds in CH_4. In the interstice between these spheres—it is a hole with an electron-pair coordination number of 4, hereafter to be referred to as a tetrahedral hole—is to be imagined the carbon nucleus surrounded by its inner, *k*-shell pair. This pair may be represented by a fifth sphere very much smaller in size than the four valence-shell pairs; this has not been done, however, in most of the drawings in this paper. The proton of a hydrogen atom of a C—H bond in CH_4 is to be imagined

[3] Einstein said " . . . there is no completely logical way to a new idea." Nonetheless, it is one of the goals of theoretical chemistry to provide for chemical models a logical justification based upon deductive arguments from accepted principles.

[4] If one does invoke coulombic repulsions between electrons as the primary reason for the tetrahedral arrangement, then, in view of the fact that it is generally believed that spin does not affect the form of the electrostatic law of force between two electrons, there arises the further question: Why do not electrostatic repulsions between electrons of opposite spin manifest themselves in a similar fashion?

[5] Dr. Kimball has kindly pointed out to the author that the tangent-sphere model used by him and his students may be considered to be "a special case of the molecular orbital model, derivable from a single antisymmetrized product of one-electron orbitals (Slater determinant). Its unique properties stem from the abandonment of the usual atomic orbitals in favor of nonoverlapping orbitals."

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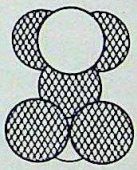
as lying about halfway between the center of the sphere that represents the C—H bond and this sphere's outer edge on a line that passes through the sphere center and the carbon nucleus.

Figure 5 is a drawing of the tangent-sphere model of ethane. In viewing such models it is helpful to remember that each sphere in the three-dimensional model corresponds to one of the lines (or sometimes a pair of dots) in the two-dimensional valence-bond diagram of the corresponding molecule. In the present model the three top and three bottom spheres represent the electron pairs of the carbon-hydrogen bonds; as before, each of these spheres is to be imagined as having imbedded within it a proton at approximately the location previously described for methane. The ethane model can be made by stacking a trigonal set of three on top of a tetrahedral arrangement of four. A more elegant method of achieving the same result is described below.[6]

The ethane model may be viewed as composed of fragments of layers of closely packed spheres. The three spheres that represent the C—H electrons of the bottom methyl group in Figure 5, for example, constitute a fragment of a layer of close-packed spheres. Upon this fragment is stacked a one-sphere layer (the carbon-carbon bond) followed by another layer of three for the C—H electrons of the second methyl group. Since the stable configuration of the two methyl groups with respect to each other as viewed along the carbon-carbon bond is the staggered configuration shown in Figure 5—this configuration is about 3 kcal/mole more stable than an eclipsed configuration, which is obtained by rotating one of the methyl groups 60° about its three-fold axis of symmetry—the stacking arrangement just described may be denoted as ABC. This is the kind of stacking of close-packed layers that occurs in cubic close packing.

Fig. 6



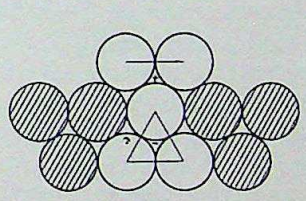


Fig. 7

Figure 6. Tangent-sphere model of ethane showing a set of five spheres whose centers lie in a plane.

Figure 7. Two-dimensional projection of a planar, five-sphere set from the tangent-sphere model of ethane (Fig. 6). The spheres whose centers are connected by the equilateral triangle are part of a preassembled trigonal set; similarly the line indicates a preassembled digonal set.

Because the tangent-sphere model of ethane is a fragment of a cubic-close-packed lattice, the sphere centers of a pair of spheres of one methyl group, the carbon single-bond sphere, and the pair of spheres of the second methyl group opposite the first pair lie in a plane, Figure 6. These five spheres are represented in Figure 7 as they might be assembled on a flat surface from a trigonal set and a digonal set with the aid of two buttressing trigonal sets. Placement of a sixth sphere above the top trigonal hole and of a seventh beneath the lower one (indicated by the "+" and "−" signs, respectively) completes the model of ethane. This simple technique can be readily extended to more complex molecules. In propane, for example, the centers of seven of the ten valence-shell spheres lie in a plane. The sphere locations in this plane, the "principal plane" of propane, are indicated in Figure 8.

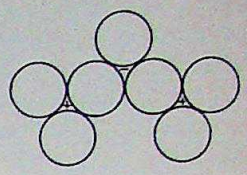


Figure 8. Tangent-circle representation of the principal plane of propane. Placement of two spheres above the trigonal holes labeled "+" and a third sphere below the hole labeled "−" completes the model.

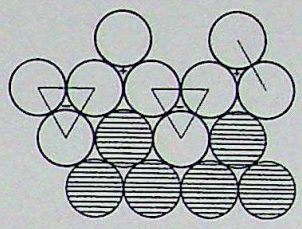


Fig. 9

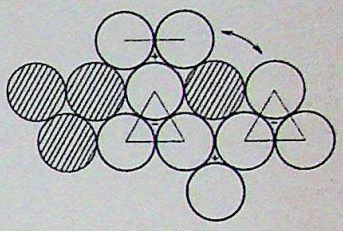


Fig. 10

Figure 9. Construction of the *trans*-confomer of *n*-butane. The three inner spheres in the middle row represent the electron pairs of the carbon-carbon bonds. That their centers fall on a straight line can be seen also from the projection diagram.

Figure 10. Construction of the gauche- or skew-confomer of *n*-butane. The center of the spheres that represent the carbon-carbon bonds do not lie on a straight line (see, also, the projection diagram). The arrow indicates the so-called "skew butane" interaction (*20*).

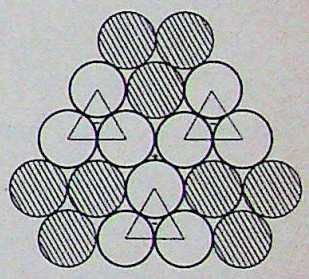
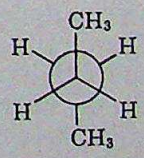
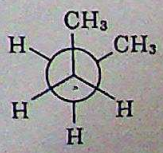


Figure 11. Construction of iso-butane. The carbon-carbon bonds are represented by the three inner spheres.

Figures 9 and 10 illustrate the construction with the aid of buttressing spheres of the *trans* and gauche confomers of normal butane. Construction of isobutane is illustrated in Figure 11. The principal planes of these three molecules contain as shown the centers of nine of the thirteen valence-shell spheres of C_4H_{10}. The structures of *trans* and gauche *n*-butane as seen in projection along the central carbon-carbon bond are shown below.



trans confomer



gauche or skew confomer

n-butane

[6] In Figure 5 the carbon-carbon bond sphere is drawn the same size as the protonated spheres. Strictly speaking these spheres are not the same size. The optimum radius of a carbon-carbon bond sphere—as determined, for example, by minimizing (subject to the tangent-sphere condition) the total molecular energy with respect to the radius of the carbon-carbon bond represented as a uniformly charged spherical charge cloud—is generally not the same as the optimum radius of the adjacent protonated spheres. Since, however, the difference is usually relatively small, and since model construction by the methods described herein is greatly facilitated when all spheres are the same size, we have in the illustrations in this paper used the zeroth-order, equal-sphere-size approximation. This approximation is probably least applicable to molecules with multiple bonds.

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Figure 12 is the tangent-circle representation of the principal plane of the chair confomer of cyclohexane. The carbon ring is puckered. Three of the carbon nuclei, those in the tetrahedral holes formed from the trigonal holes labeled "+," lie in a plane parallel to and above the principal plane while the other three nuclei lie in a parallel plane beneath the principal plane (*20*). The orientation of the six spheres about each carbon-carbon bond is the same as that in ethane in its equilibrium configuration (Fig. 7). This is not the case for the boat confomer of cyclohexane (see below).

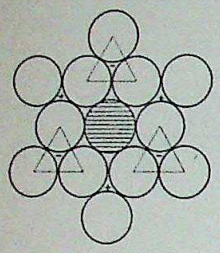


Fig. 12

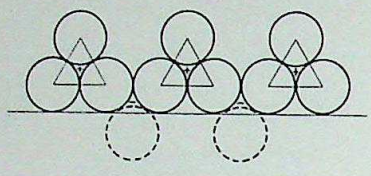


Fig. 13

Figure 12. Construction of the chair confomer of cyclohexane. The inner six spheres represent the electrons of the carbon-carbon bonds, the outer six the electrons of the equatorial carbon-hydrogen bonds. To complete the model, six more spheres must be added, three above the principal plane and three below it; these represent the electrons of the bonds to the polar (or axial) hydrogen atoms.

Figure 13. Construction of *n*-pentane in its all-*trans* conformation. The six spheres of the "principal line" (the middle row) are the backbone of the structure. Once these are in place it is relatively simple to place properly the model's remaining ten spheres.

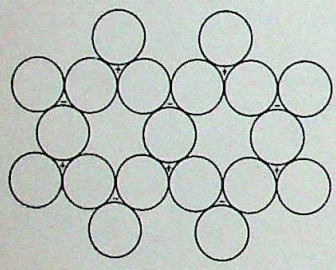


Fig. 14

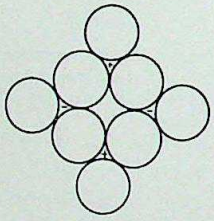


Fig. 15

Figure 14. Tangent-circle representation of the principal plane of *trans*-decalin. Both six-membered rings are in their chair configurations (cf. Fig. 12). The hydrogen atoms on the two carbon atoms common to the rings are trans to each other; one is above the principal plane, the other below it. The model contains two principal lines (the second and fourth rows) upon which its construction can be based.

Figure 15. Tangent-circle representation of the principal plane of cyclobutane. Note that the four-membered ring is puckered. The inner four circles represent the carbon-carbon bonds, the outer four the equatorial carbon-hydrogen bonds.

Figure 13 shows that in making models of the normal paraffins in their all-*trans* configurations a straight-edge can be used to advantage in lining up the trigonal components. Alternatively, the "principal line" in these models can be preassembled on the groove of an inexpensive slide rule and the construction of the principal plane initiated from that point.

The principal plane of *trans*-decalin (*20*) is illustrated in Figure 14. This plane can be constructed in a manner analogous to that described previously for the chair confomer of cyclohexane (Fig. 12). It can also be constructed from the components of *n*-pentane (see Fig. 13). One advantage of the latter method of construction is that it can be extended with suitable modifications to the construction of models of the less stable confomers of decalin and of the corresponding confomers of such more complex perhydroaromatics as perhydroanthracene and perhydrophenanthrene (*21*). In the simpler case of cyclohexane a model of the less stable boat confomer can be made from the structural unit shown in Figure 8 by placing two such units opposite each other with additional spheres acting as spacers at the positions marked "+."

The principal plane of cyclobutane is indicated in Figure 15.

Figure 16 illustrates the construction of the tangent-sphere model of ethylene. The principal plane in ethylene contains the centers of four spheres: two from the double bond and two from *trans* C—H bonds. In the tangent-sphere representation of ethylene the two components of the double bond are represented as equivalent bent bonds.

In Figure 17 is pictured the principal plane of propylene. In the completed model the orientation of the six spheres bordering on the carbon-carbon single bond is the same as that in ethane (Fig. 7). This means that as the methyl group rotates about its

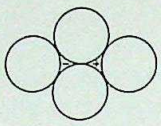


Fig. 16

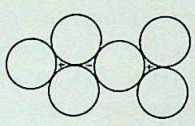


Fig. 17

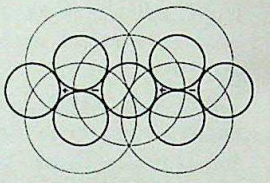


Fig. 18

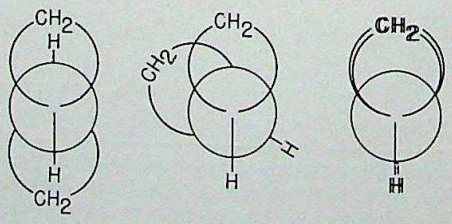
Figure 16. Principal plane of ethylene. The two inner circles which touch each other represent the components of the carbon-carbon double bond.

Figure 17. Principal plane of propylene. The spheres shown represent, from the left, respectively, a C—H bond of the methylene group, the two components of the carbon-carbon double bond, the carbon-carbon single bond, and two of the C—H bonds of the methyl group.

Figure 18. Principal plane of *trans*-1,3-butadiene. Large circles are used to locate the centers of the smaller tangent circles, which represent, from left (or right), these bonds: C—H (methylene), C=C, C—C, C=C, C—H (methylene).

threefold axis one of its C—H bonds, the one in the completed model that points toward the reader in Figure 17, reaches its position of closest approach to the adjacent methylene C—H bond when the methyl group as a whole has reached its most stable orientation. Possibly this is one reason why the barrier to rotation of the methyl group in propylene is only about two-thirds as great as it is in ethane.

Figure 18 shows the principal plane of 1,3-butadiene for the molecule in its trans configuration (adjacent double bonds trans to each other with respect to the



Trans Gauche (Cis)

Figure 19. Projection diagrams for three confomers of 1,3-butadiene. Projections are along the carbon-carbon single bond. Curved lines to the CH_2 groups represent the equivalent-orbital components of the double bonds. Relative conformer stabilities are probably *trans* > gauche ≫ *cis*. (Since this remark was written, the microwave spectrum of fluoroprene ($CH_2{=}CHCF{=}CH_2$) has been reported by D. R. Lide, Jr. (*J. Chem. Phys.*, *37*, 2074 (1962)). The molecule, as expected, has a planar *trans* configuration in the ground state. No specific search was made for the spectrum of a nonplanar isomer. The *cis* isomer was searched for but not found.)

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single bond joining them). As in ethane, the terminal points on opposite sides of the carbon-carbon single bond are staggered with respect to each other. The same is true for the corresponding gauche or skew configurations but not for the *cis* configuration, Figure 19. Figure 20 shows the principal plane of the all-*trans* confomer of 1,3,5-hexatriene.

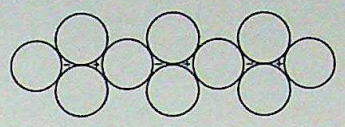

Figure 20. Principal plane of all-*trans* 1,3,5-hexatriene. Circles, from left or right, represent respectively the bonds C—H (methylene), C=C, C—C, C=C, C—C, C=C, C—H (methylene).

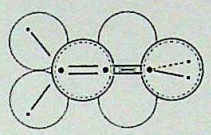

Figure 21. Tangent-sphere model of allene ($CH_2{=}C{=}CH_2$) superimposed upon its valence-bond diagram. The three heavy dots represent the carbon cores; the four light dots, the protons. As inferred by van't Hoff in 1875 the molecule is nonplanar. (*Cf.* Skell, P. S., and Westcott, L. D., *J. Am. Chem. Soc.*, *85*, 1023 (1963), for a description of the isomers of *bis*-ethanoallene that are formed by the low-temperature addition of C_3, a dicarbene, to olefins.)

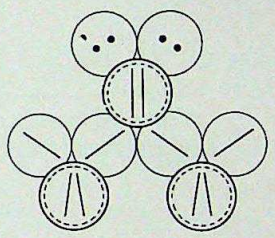

Figure 22. Tangent-sphere model of the equilibrium configuration of acetone superimposed upon the molecule's valence-bond diagram. The four heavy dots represent the unshared pairs on the oxygen atom. Removal of these two pairs leaves behind the tangent-sphere representation of the electron cloud of propane, or of ethyl alcohol, dimethyl ether, oxygen difluoride, and other molecules isoelectronic with propane. The orientation with respect to each other of the two trigonal sets at either end of a carbon-carbon single bond is the same as in ethane. The orientation of the methyl groups with respect to the double bond is the same as in propylene.

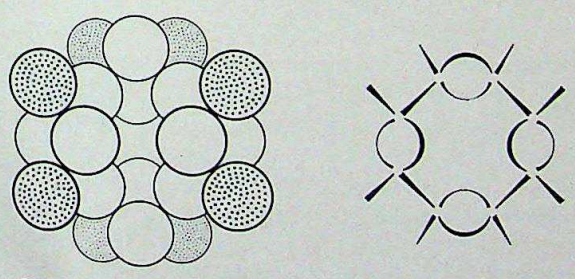

Figure 23. Tangent-sphere model and valence-bond diagram of 1,3,5,7-cyclooctatetraene

CH=CH—CH=CH—CH=CH—CH=CH

Stippled spheres represent carbon-hydrogen bonds, open spheres carbon-carbon bonds. The model is a fragment of five layers of a cubic-close-packed lattice. Interestingly, the carbon-carbon single bonds in this nonplanar, tub-shaped molecule are perhaps 0.01–0.02 Å shorter than the carbon-carbon single bond in planar 1,3-butadiene. This fact, which is anomalous from the view point of current theory (Cf. Bastiansen and Traetteberg (p. 147), Cruickshank (p. 155), and Coulson, C. A., *Tetrahedron*, *17* 256 (1962)), can be accounted for, in part, by considering the vector displacements of the doubly-bonded carbon nuclei from the centers of their tetrahedral holes. These displacements are described below in more detail in the section on the effects of multiple bonds on molecular geometry.

To summarize, construction of tangent-sphere models requires a supply of spheres, glue, and a flat surface. A box half-full of spheres makes a useful "jig" for holding partially completed models in desired orientations. Useful, also, are preassembled trigonal and diagonal sets and a valence-bond diagram of the molecule under consideration. For lecture demonstrations models made from 3–4-in. diameter Styrofoam spheres are suitable. Lucite or Plexiglas spheres can be obtained in attractive colors[7] for color coding bonds; the $^1/_2$-in. size glues easily with Duco or some similar quick-drying, ketone- or ester-based cement. For student use $^1/_2$-in. cork balls[8] work very well. They are light, inexpensive, and easy to handle.

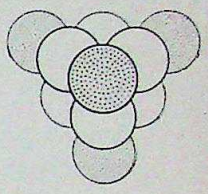

Figure 24. Tangent-sphere model of P_4. Stippled spheres represent unshared pairs, open spheres phosphorus-phosphorus single bonds. Each phosphorous atom has in its valence shell one unshared pair and three pairs with which it forms single, bent-bonds to its three neighbors.

Additional molecules whose models are interesting to make are allene (Fig. 21), carbon suboxide, acetone (Fig. 22), 1,3,5,7-cyclooctatetraene (Fig. 23), cyanogen, tetracyanoethylene, bicyclo-(2.2.2.)-octane, P_4 (Fig. 24), P_4O_6, P_4O_{10}, and diamond.

Literature Cited

(1) Pekeris, C. L., *Phys. Rev.*, **112**, 1649 (1958).
(2) Stewart, E. T., *Ann. Repts. Chem. Soc.*, (*Lond.*), **58**, 7 (1961).
(3) Platt, J. R., "Handbuch der Physik," Springer-Verlag, Berlin, 1961, Vol. 37/2, p. 173.
(4) Hartree, D. R., "The Calculation of Atomic Structures," John Wiley and Sons, Inc., New York, 1957, pp. 16–7.
(5) Dirac, P. A. M., *Camb. Phil. Soc.*, **26**, 376 (1930); *ibid.*, **27**, 240 (1931); see also ref. (*3*), p. 177.
(6) Wilson, E. B., Jr., *J. Chem. Phys.*, **36**, 2232 (1962).
(7) (*a*) Feynman, R. P., *Phys. Rev.*, **56**, 340 (1939); (*b*) Berlin, T. J., *J. Chem. Phys.*, **19**, 208 (1951); Longuet-Higgins, H. C., and Brown, D. A., *J. Inorg. Nucl. Chem.*, **1**, 60 (1955); Bader, R. F. W., and Jones, G. A., *Can. J. Chem.*, **39**, 1253 (1961).
(8) James, H. M., and Coolidge, A. S., *J. Chem. Phys.*, **1**, 825 (1933).
(9) Kimball, G. E., and Loebl, E. M., J. Chem. Educ., **36**, 233 (1959).
(10) Wigner, E., and Seitz, F., *Phys. Rev.*, **43**, 804 (1933); *ibid.*, **46**, 509 (1934).
(11) Slater, J. C., *Phys. Rev.*, **81**, 385 (1951).
(12) Ruedenberg, K., *Revs. Mod. Phys.*, **34**, 326 (1962); Kauzmann, W., "Quantum Chemistry," Academic Press, Inc., New York, 1957, p. 320.

[7] Ace Plastic Co., 91-38 Van Wyck Expressway, Jamaica 35, N. Y.; Auburn Plastic Engineering, 4916-24 South Loomis St., Chicago 9, Ill.

[8] Cork Products Co., Inc., 239 Park Ave., South, New York 3, N. Y.

Editor's Note: The second part of this paper will appear in the October, 1963 issue. In it Professor Bent will discuss uses of the tangent sphere models as devices for depicting a wide variety of structural features and concepts. Figures 25–40 and literature citations 22–41 will appear with the second article.

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(13) Zimmerman, H. K., Jr., and Van Rysselberghe, P., *J. Chem. Phys.*, **17**, 598 (1949); Linnett, J. W., and Poe, A. J., *Trans. Far. Soc.*, **47**, 1033 (1951); Mellish, C. E., and Linnett, J. W., *Trans. Far. Soc.*, **50**, 657, 665 (1954).
(14) Linnett, J. W., *J. Am. Chem. Soc.*, **83**, 2643 (1961).
(15) *Cf.* Daudel, R., Brion, H., and Odiot, S., *J. Chem. Phys.*, **23**, 2080 (1955).
(16) (*a*) Kleiss, L. M., "Calculations of Properties of Hydrides of Second-Row Elements," Thesis, Columbia University, 1952, *Diss. Abs.*, **14**, 1562 (1954); *C.A.*, **49**, 3584*c* (1955); (*b*) Westerman, H. R., "Simplified Calculations of the Energies of Second-Row Elements," Thesis, Columbia University, 1952. *Diss. Abs.*, **15**, 350 (1955); *C.A.*, **49**, 7303*d* (1955); (*c*) Herniter, J. D., "Kinetic Energy of Mechanical Elements," Thesis, Columbia University, 1956, *Diss. Abs.*, **16**, 2040 (1956); *C.A.*, **51**, 9285*h* (1957).
(17) Platt, *op. cit.*, pp. 258–9.
(18) "Application of Wave Mechanics to Chemistry," a lecture given by George Kimball to the CBA project July 20, 1959.
(19) Strong, L. E., J. Chem. Educ., **39**, 126 (1962).
(20) Dauben, W. G., and Pitzer, K. S., in "Steric Effects in Organic Chemistry," Newman, M. S., ed., John Wiley and Sons, Inc., New York, 1956, chap. 1.
(21) Eliel, E. L., "Stereochemistry of Carbon Compounds," McGraw-Hill Book Co., Inc., New York, 1962, pp. 282–5.

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An Inexpensive Spectrograph of Moderately High Resolution

A number of spectrographic experiments exist which quantitatively demonstrate aspects of quantum chemistry. For most experiments, however, the cost of a spectrograph which has the necessary resolution is prohibitively high. This article describes a spectrograph with a resolving power greater than 6000 which can easily be built for a cost of parts less than $80. Experiments can be performed with this spectrograph which are applicable to courses ranging from high school science to college experimental physical chemistry.

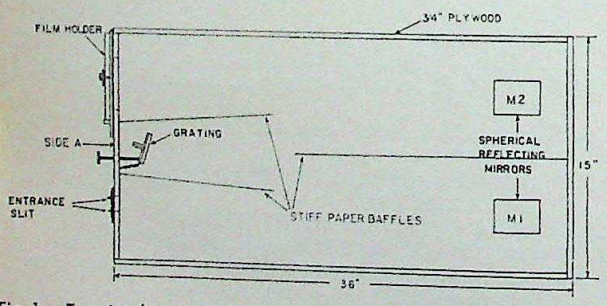

Fig. 1. Top view (cover removed).

Spectrograph

Construction. The spectrograph uses the monochromator of Ebert (*1*). Its construction is similar to that described previously for a spectrophotometer (*2*). An over-all view of the spectrograph is shown in Figure 1. Figures 2–5 show details of the important parts. Table 1 identifies the parts in the first five figures and indicates their source and cost. The construction of the spectrograph is sufficiently described in these figures that a detailed explanation of the construction is unnecessary. It should be noted that none of the dimensions is particularly critical. Students can easily construct these housings.

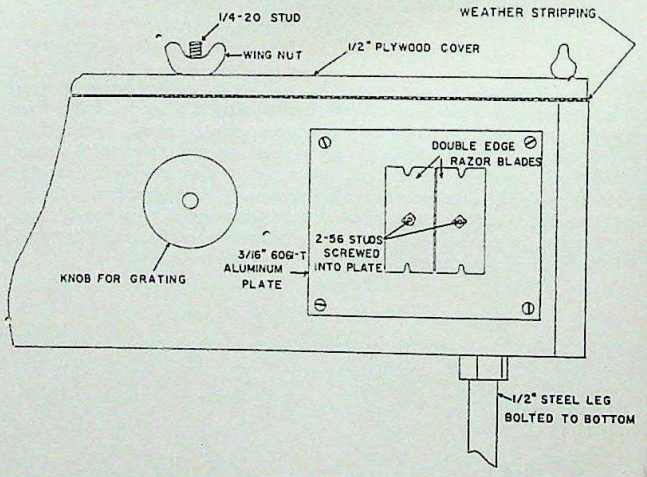

Fig. 2. Entrance slits detail.

Alignment. To focus the spectrograph the reflecting surface of $M1$ is adjusted to 30 in. from the slit. Then, in a darkened room, a shielded light bulb is placed before the slit and moved laterally until its image falls squarely on mirror $M1$. A white card is placed in front of the grating, facing $M1$, and $M1$ is adjusted until the light through the slit falls squarely on the grating. The grating is rotated until it is nearly parallel with the side on which the slits are mounted. The white card is then placed in front of $M2$ and the

We would like to express our appreciation to the Course Content Improvement Section of the Special Projects in Science Education branch of the National Science Foundation.

[1] This paper is taken in part from the BA thesis of R. Schoenbeck, Reed College, 1962.

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grating adjusted until the card is fully illuminated with white light. (It may be necessary to adjust the tilt of the grating.) This position of the grating corresponds to the zeroth order. $M2$ is adjusted until the image of the first slit is centered in the 1-in. × 5-in. slot in side A where the film holder is clamped.

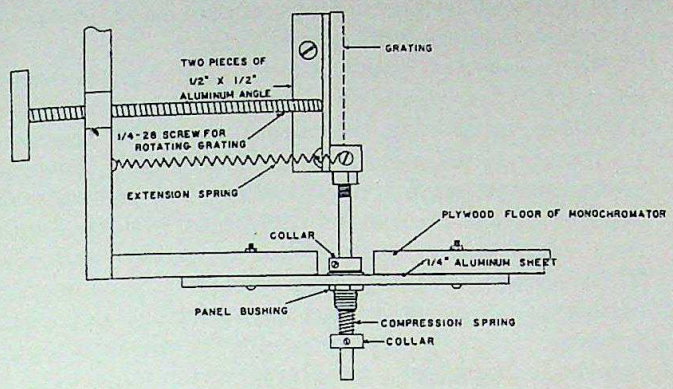

Figure 3. Grating mount detail.

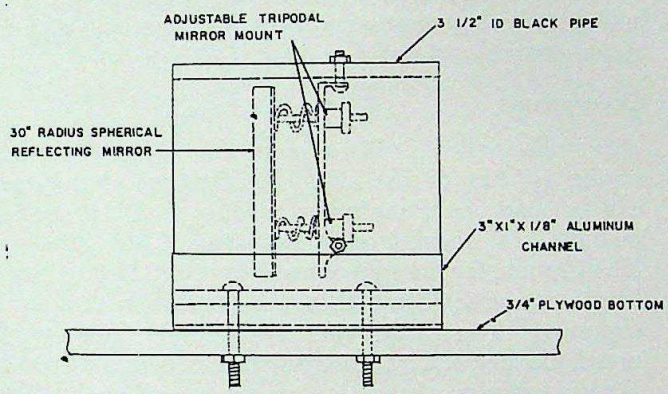

Figure 4. Cross section of spherical reflecting mirror assembly.

The final focusing of the spectrograph is performed visually, then photographically. The light bulb is replaced with a GE 275 watt sun lamp. A translucent sheet of cellophane or glass is taped to the outside of the slot at the same distance from $M2$ that the film will be. The grating is rotated until the first order spectrum comes into view. Mirror $M2$ is adjusted until the lines appear sharpest. A very fine opening in the slit is advisable for this adjustment. Finally the spectrum of the iron arc is photographed for minor changes in the setting of $M2$. The setting which shows the maximum separation of lines is chosen from an examination of the exposures. The spectrograph is now focused for any rotation of the grating. Because of the long focal length of the mirrors, an error of 1–2 mm in the adjustment of $M2$ does not have a significant effect on the resolution.

Calibration. The calibration of a spectrum in wavelength is accomplished by a multiple exposure (*3*). Half of the length of the slit is covered with tape and an exposure taken. Then the tape is moved to the other half and an exposure of a known source, usually mercury (sun lamp), is taken. The lines in the known spectrum are identified. A linear dispersion is assumed and a plate factor in angstroms per millimeter of film determined. The wavelengths of unknown lines are then determined by interpolation. Actually, the plate factor is not exactly linear. Since the film is held flat and not curved along a radius from $M2$, the plate factor will decrease symmetrically around the center of the film. This deviation can be determined from a known spectrum. A reasonable plate factor (21 Å/mm) is used to measure wavelengths from the edge of the spectrogram nearest the grating. The correction in angstroms, which must be added to the measured wavelengths to obtain the correct wavelength, is plotted in Figure 6. These corrections are obtained from an examination of the known lines in an iron arc spectrum and they vary as $M2$ is shifted. This correction graph is applicable to any rotational position of the grating. Measurements of other portions of the iron spectrum have an accuracy of 0.25 Å with the use of such a graph. Adequate accuracy is possible by using only a single experimentally determined plate factor and interpolating from the nearest mercury line. The results which are cited in the experimental section were determined using the latter method.

Table 1. Optical Parts List for Spectrograph

Part	Amount	Supplier	Total cost($)
3-in. spherical mirror Cat. No. 50082	2	Edmund Scientific Co., Barrington, New Jersey	15.30
3 in. mirror mount kits Cat. No. 50169	2	...	5.90
Plane reflecting grating 2 in. × 2 in., 15,000 lines/in (Jarrell-Ash) Cat. No. 30320	1	Jarrell-Ash Co. 26 Farwell Street, Newtonville 60, Mass.	50.00

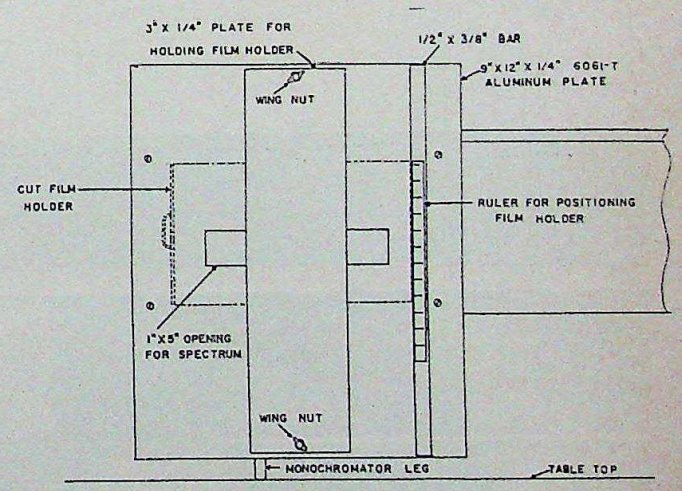

Figure 5. Film holder detail.

Performance. Czerny and Turner (*4*) demonstrated that a symmetrical optical system like the Ebert monochromator is theoretically free of aberrations. The lack of distortion in addition to the long focal length of the mirrors results in a spectrograph which can produce remarkably sharp spectra very easily. An examination of the iron spectrum with the traveling

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microscope has revealed that two lines which are 0.7 Å apart (4408.42–4407.72, 4250.7–4250.13) can be resolved whereas a 0.3 Å separation (4233.61–4233.95) is unresolved. A separation of 0.7 Å at 4400 Å corresponds to a resolving power of 6300.

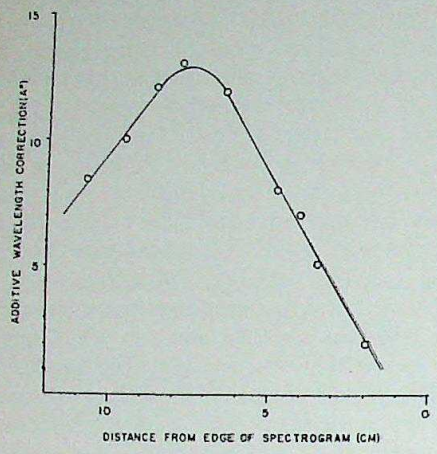

Figure 6. A calibration curve for the spectrograph.

The resolution can be enhanced at the expense of intensity by using higher orders of the grating. In doing this one must use caution since overlapping orders produce a very confusing spectrum. If a filter is inserted between the source and the slit, the unwanted orders can be eliminated, however, at an additional expense in intensity. Although we have not exploited this in our measurements, the resolution to be gained is demonstrated in Figures 7*a*, *b*, *c*, and *d*. These are the spectra caused by the intense emission of CN in a carbon arc in air. A blue filter (blue cellophane which transmits between 3600 Å and 4700 Å) was used and

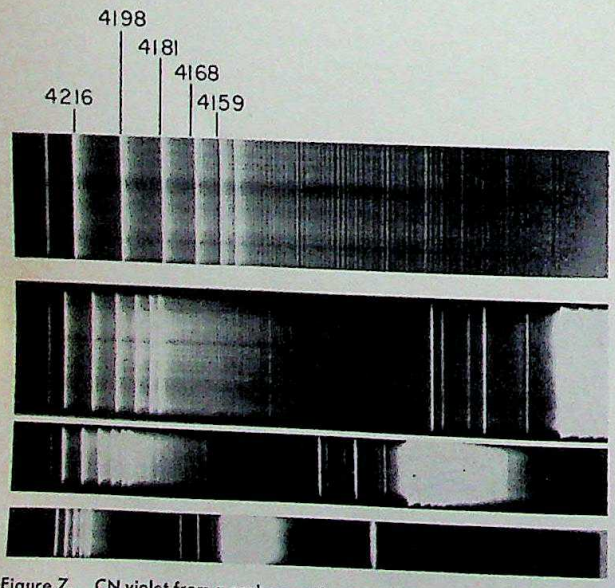

Figure 7. CN violet from a carbon arc in air:
(*a*) first order, panatomic X, smallest slit opening possible, 2 second exposure
(*b*) second order, Panatomic X, smallest slit opening possible, 1 minute exposure
(*c*) third order, Panatomic X, smallest slit opening possible, 4 minutes exposure
(*d*) fourth order, Royal Pan, smallest slit opening possible, 4–8 minutes exposure
Throughout this work all films were developed with DK-70 developer.

rotation made in the first, second, third, and fourth orders. Note that in the first order the region between 4216 Å and 4198 Å appears to be a continuum but by the fourth order it has developed into definite rotational fine structure.

It should be noted that the spectrograph has all reflecting optics. Consequently it is usable in any spectral region. Our photographic measurements have been confined by the use of commercial sheet film to the region between 2980 Å and 6234 Å.

Measurement of Spectral Lines. Three methods were compared for measuring distances between lines. All three involved a magnification of the spectrum. A traveling microscope was first used; however, measurements were tedious, which, coupled with the expense of the microscope, detracted from its general use. Next a densitometer was assembled and used. This had the advantage of a quantitative comparison of intensity but offered no advantage in wavelength accuracy. Finally, and most simply, white paper was taped to a blackboard and the spectrum projected onto it with a lantern slide projector. The lines of interest were marked on the paper and subsequently measured with a ruler. A comparison in accuracy of the three methods is described in the iodine experiment. It is sufficient to say here that the third method was the most accurate.

Experiments

Fraunhofer Lines (*5*). One of the easiest spectra to obtain is that of the sun. Satisfactory photographs can be made on Panatomic X film using the smallest possible slit opening and less than 1 sec exposure. The Fraunhofer lines are spread over too large a wavelength range to obtain them on the film with a single exposure. The grating must be rotated. It should be noted that for equivalent resolution a more narrow slit is required in an absorption spectrum such as this than in an emission spectrum.

Balmer Lines (*6*). The Balmer lines, like the Fraunhofer lines, require two exposures as shown in Figure 8. The spectra were obtained from a Geissler tube using for power a neon sign transformer whose primary voltage was controlled by a variable transformer. A 100 ohm resistor was placed in series with the tube and

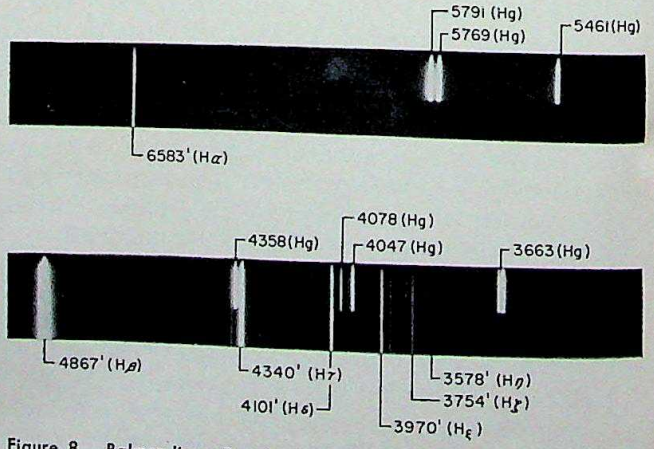

Figure 8. Balmer lines, Panatomic X, slit 0.5 mm (wide), exposure time 10 minutes. The prime (') indicates the experimental value based on interpolation from mercury lines.

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Table 4. Results of Swan Band Spectrum[a]

	ω_e''(cm^{-1})	ω_e'(cm^{-1})	$\omega_e''x_e'$(cm^{-1})	$\omega_e'x_e'$(cm^{-1})
Calculated	1607	1760	8.	23.2
Herzberg (*8e*)	1641	1788	11.7	16.4

[a] Measurements based on traveling microscope method.

Table 5. Summary of Iodine Results[a]

Source	ω_e''	$D_0^{\circ b}$	ω_{00}	$\omega_L(E^*)$	$D_0'^b$	ω_e'	$\omega_e'x_e'$	Te^b
Densitometer		12,315	15,532	19,913	4,381	133	1.045	
Projection	215.9	12,317	15,591	19,915	4,324	127.7	0.970	15,635
Traveling microscope		12,371	15,543	19,969	4,426	129	0.921	
Herzberg (*8d*)	214.6	12,440	15,598.3	20,037	4,439	128	0.834	15,641.6

[a] All values are in cm^{-1}.
[b] Te is the energy separation between the potential minima of the two states. D_0° is the heat of dissociation of the lower state and D_0' of the upper state.

the current through the secondary adjusted to 10–20 ma as measured by a vacuum tube voltmeter across the resistor. H_α in Figure 8 is due to the transition $n = 3$ to $n = 2$. H_β is due to $n = 4$ to $n = 2$, etc. By plotting the frequency in wave number versus $1/n^2$, where n is the quantum number of the initial state, a straight line is obtained whose slope is the Rydberg constant. The value in wave numbers for $n = \infty$ corresponds to the ionization energy from the $n = 2$ level. Table 2 is a tabulation of the results obtained. It should be noted that the isotopic shift in the spectrum for H^2 predicted in the derivation of the Rydberg constant should be easily resolved with this spectrograph. A mixture of H^1 and H^2 would yield a spectrum of doublets. A wide slit (*ca.* 0.5 mm) was used to detect the less intense lines in the series.

Table 2. Results of Balmer Spectrum[a]

	Rydberg constant
Graphical	11.1 $\times 10^4$ cm^{-1}
Least squares	11.01 $\times 10^4$ cm^{-1}
Accepted value	10.9678 $\times 10^4$ cm^{-1}

[a] Measurements based on projection method.

C_2 Swan Bands. The radical, C_2, which is found in carbon arcs and hydrocarbon flames has a characteristic emission in the region from 4380 to 6190 Å. An oxyacetylene flame is a convenient source. Exposures were made with the smallest slit possible for about one hour on Panatomic X film. The spectrograph has sufficient resolution to show clearly the vibrational progressions and considerable fine structure due to rotational transitions. An analysis of this spectrum to obtain vibrational constants for the upper electronic state of C_2 has been described in detail elsewhere (*7, 8a*). To explain briefly, equations (1) and (2) are each substituted with the data from three lines yielding six equations with six unknowns.

$$\omega_{v''v'} = K - (v'\omega_e' - v'^2\omega_e x_e) \quad \text{for constant } v' \qquad (1)$$

$$\omega_{v''v'} = K' - (v''\omega_e'' - v''^2\omega_e'' x_e'') \quad \text{for constant } v'' \qquad (2)$$

In these equations $\omega_{v''v'}$ is the energy in wave numbers of the line produced by a transition from the upper level of vibrational quantum number v' to the lower level, v''. ω_e' and ω_e'' are the vibrational frequencies in wave numbers for the upper and lower states respectively, and $\omega_e'x_e'$ and $\omega_e''x_e''$, the first order anharmonicity corrections. K and K' are constants for a constant v' and v'' respectively. $\omega_{v''v'}$ for the observed transitions between v'' and v' levels are conveniently tabulated as shown in Table 3 (a DesLandres Table). Using this data, Table 4 gives a comparison of the experimental results.

Table 3. DesLandres Table of Swan Band Measurements

v'/v''	0	1	2	3	4
0	1.935[a]	1.774	...	...	...
1	2.108	1.948	1.790	...	...
2	...	2.125	...	1.805	...
3	...	...	2.131	...	1.817
4	...	...	...	2.134	...

[a] All values $\times 10^4$ cm^{-1}.

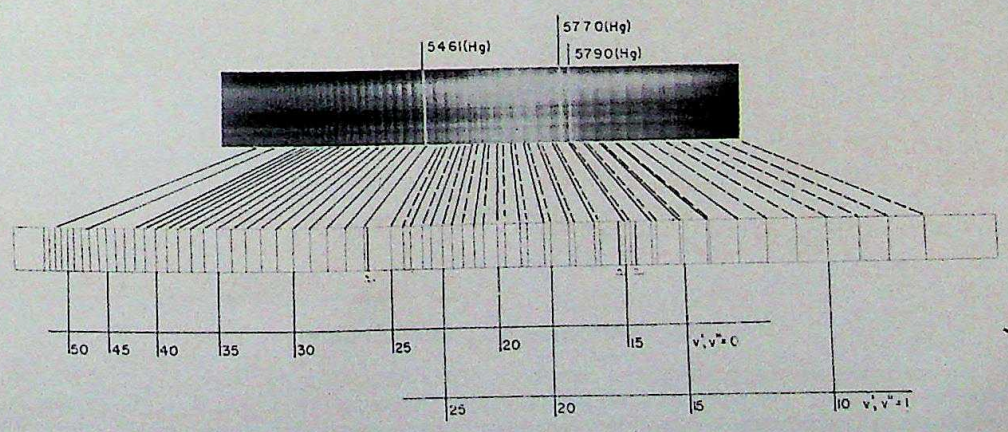

Figure 9. Absorption spectrum of iodine: Panatomic X, smallest slit possible, slightly less than one minute exposure.

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Table 6. Results of Raman Spectrum of Liquid Benzene

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Exciting line wavelength (A)	Wavelength of v_1(A)	$\Delta\nu$(cm^{-})	Wavelength of v_2(A)	$\Delta\nu$(cm^{-1})
4358	4551	975	5021	3031
4047	4215	991	4611	3025
3663	3799	981	4127	3085
3655	3786	949	4107	3014
3650	3776	914	4097	2989
Accepted Value (*11*)		992		3063

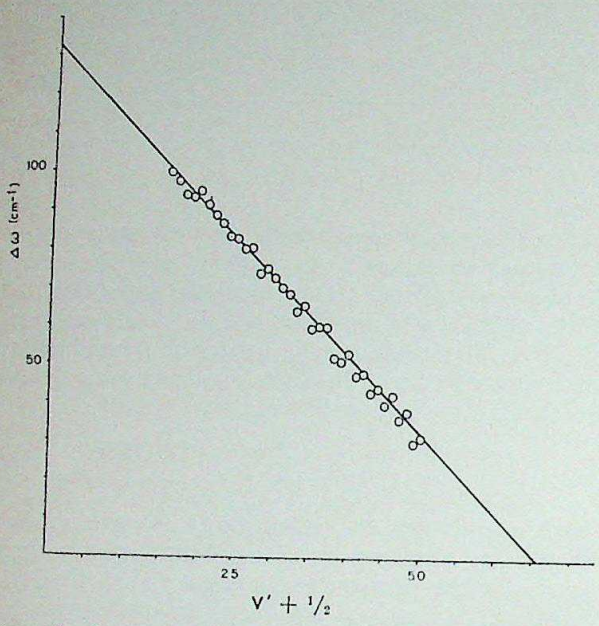

Figure 10. Graphical determination of the heat of dissociation of iodine: experimental slope ($\omega_e'x_e'$), 0.970 cm^{-1}; heat of dissociation of upper electronic state (D_0'- area under line), 4324 cm^{-1}; heat of dissociation of lower electronic state ($D_0^\circ = \omega_L$ — difference in dissociation limits, 7598 cm^{-1}), 12,317 cm^{-1}.

I_2 Absorption Spectrum. Iodine like all diatomic halogens has an absorption spectrum whose lines merge into a continuum representing the dissociation limit (*8b, 9*). Figure 9 is an absorption spectrum of gaseous iodine. The iodine spectrum was obtained by passing the light from a 100 watt projection bulb through a tube 20 cm long and 25 mm wide which was close to the slit. The ends of the tube were sealed fairly flat and some iodine introduced through a small side arm. Sufficient iodine vapor was obtained by heating the tube with a low wattage light bulb placed beneath the tube. Most of the molecules exist in the lowest vibrational level of the ground electronic state ($v''=0$). The absorption lines correspond to a sequence of transitions from this level to $v'=0$, $v'=1$, $v''=2$ etc., until finally the v_L' level is reached which is the dissociation limit. Although the temperature of the cell was only 30–40°C, the $v''=1$ state is also significantly populated so that transitions from it are also evident. The manner in which the heat of dissociation of the ground state of iodine and the vibrational constants of both states can be calculated has been described in detail (*7, 8c, 10*). The method for iodine is inherently more accurate than C_2 since iodine has more lines and they are nearly all used in the calculation. Figure 10 shows a typical curve. Table 5 is a tabulation of the experimental values measured by the three methods described above and the accepted values for comparison.

Raman Spectrum. Although the spectrograph has the necessary dispersion for resolving Raman spectra the loss of intensity which accompanies the use of a grating makes this measurement a marginal one. A spectrum was obtained by irradiating a 1 cm diameter tube filled with liquid benzene with three GE sun lamps arranged radially about the tube. One end was sealed flat and set against the slit. The other end was shaped like a horn and taped on the outside with electrical tape to reduce the amount of scattered light. The results are tabulated in Table 6.

Literature Cited

(1) Fastie, W. G., *J Opt. Soc. Am.*, 42, 641 (1952).
(2) Tabbutt, F. D., J. Chem. Educ., 39, 611 (1962).
(3) See Harrison, G. R., Lord, R. C., and Loofbourow, J. R., "Practical Spectroscopy," Prentice-Hall, Inc., New York, 1958, chap. 9.
(4) Czerny, M., and Turner, A. F., *Z. Physik*, 61, 792 (1930).
(5) Brode, W. R., "Chemical Spectroscopy," John Wiley and Sons, Inc., New York, 1939, p. 441.
(6) Shoemaker, D. P., and Garland, C. W., "Experiments in Physical Chemistry," McGraw-Hill, New York, 1962, pp. 316–21; Herzberg, G., "Atomic Spectra and Atomic Structure," 2nd ed., Dover, New York, 1944, pp. 11–38.
(7) Davies, M. J., J. Chem. Educ., 28, 474 (1952).
(8) Herzberg, G., "Spectra of Diatomic Molecules," D. Van Nostrand and Company, 2nd ed., New York, 1955, pp. (*a*) 151–5; (*b*) 388–94; (*c*) 90–101; (*d*) 540–1; (*e*) 513.
(9) Barrow, G. M., "Introduction to Molecular Spectroscopy," McGraw-Hill, New York, 1962, pp. 230–44.
(10) Stafford, F. E., J. Chem. Educ., 39, 626 (1962).
(11) "Raman Spectral Data," American Petroleum Institute Research Project 44, Carnegie Institute of Technology, Pittsburgh, Pa., 1960.

ACS Committee on Chemical Safety

An open meeting will be held at the New York ACS meeting Monday, September 9, 2:00 P.M., Americana Hotel. The purpose of the meeting will be to discuss this subject from the standpoint of laboratory design, personnel, facilities, control equipment, safe practices, and need for education as they relate to various types of chemical activities.

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Plastic Dreiding Models

In little more than a decade, organic chemistry has taken on a new and exciting three-dimensional look. Classical stereochemistry has been expanded by introduction of the concepts of axial and equatorial bonds, conformational analysis, chair, boat, and twist forms of cyclohexane, nonbonded interactions in medium size rings, steric control of asymmetric synthesis, and steric control of reaction mechanism. An up-to-date teacher trying to get these concepts across has been pressed to find models for use in lecture demonstrations. Models which the student himself can use have been either costly and not very good or adequate but prohibitively expensive. This article describes superior models of a new type which will be available at a cost so low that beginning students can acquire models either by purchase or on loan from the storeroom.

The key piece is a half tetrahedron (Fig. 1), two of which fit together in only one way. The model is assembled (Fig. 2) by fitting an aluminum tube permanently onto the short rod of a black plastic piece and cementing together two identical units. In this model of methane, carbon is represented by the black tetrahedral piece at the center and hydrogen atoms are assumed to be centered at the ends of each rod or tube.

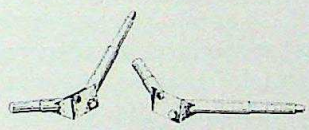

Figure 1.

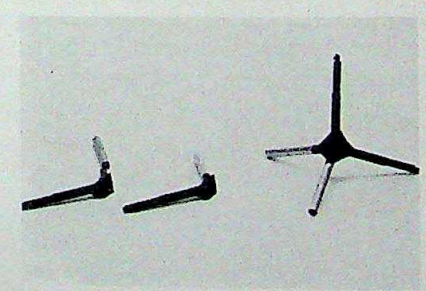

Figure 2.

When a plastic rod of one carbon is inserted into the tube of another and the two are snapped together, a button near the end of the rod engages with an indentation of the tube and holds the carbons together until they are pulled apart. The carbon atoms of ethane are free to rotate about the C—C bond, but the fit is snug enough so that the model will stay oriented in a specific conformation when desired. The C—H and C—C distances are in the ratio 1.09 Å:1.54 Å and the scale is 1 cm = 0.2 Å.

The models lend themselves well to the construction of rings containing five or more carbon atoms. Fred Kaplan suggested that, in an initial consideration of the chair form of cyclohexane, one can assemble the atoms so that black plastic rods represent the axial bonds and shiny aluminum tubes represent the equatorial ones; a ring flip reverses the situation (Fig. 3*a* → 3*b*). The ring flip of Figure 3*a* is accomplished gracefully by grasping the 1α and 5α bonds (metal) and pressing 3α against the chest. The circular pressure labels for numbering atoms can be removed and reused repeatedly.

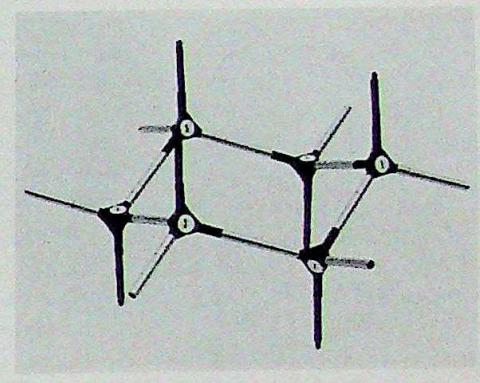

Figure 3*a*.

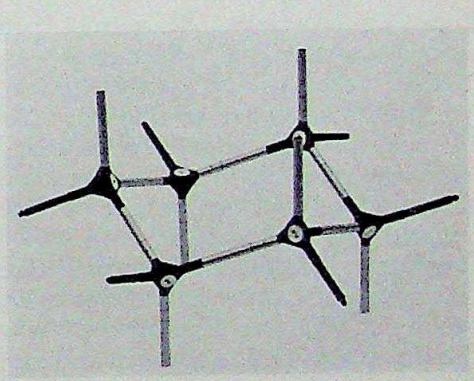

Figure 3*b*.

One can demonstrate also the ready conversion of one boat form into another and then stop halfway between the two and preserve the twist form (Fig. 4*a*, *b*, *c*). An interesting assignment is to measure 1,2-, 1,3- and bow-stern H:H distances and estimate the relative stability of the chair, boat, and twist forms. A con-

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venient measuring device can be made from a 10-cm clear plastic ruler either by taping a paper clip over the end to form a resting socket or by securing a $^{12}/_{24}$ brass nut with an epoxy resin to the under side with the hole centered at the zero point.

With ten tetrahedrons the student can make models of *cis*- and *trans*-decalin, adamantane, twistane, and norbornane. For construction of cyclopropane and cyclobutane, students should be advised not to try to bend the bonds but to use sections of $^{3}/_{16}$-in. rubber tubing for connecting unmodified tetrahedrons. A model of ethylene made in the same way shows clearly that the members of the double bond are in a plane perpendicular to the plane of the C—H bonds. Rubber-connected models of ethylene, cyclopropane, and cyclobutane on being flipped open afford an amusing demonstration of the Baeyer strain theory. Three connectors are used to form acetylene; a larger piece of tubing can be used to form a carbonyl group.

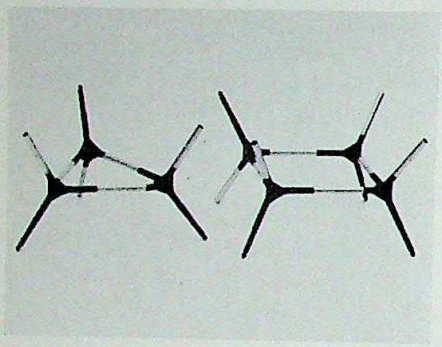


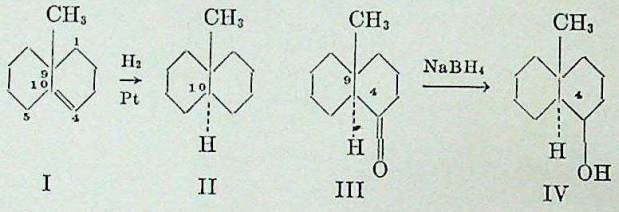
Figure 5.

A mature user wishing to construct permanent models of cyclopropane and cyclobutane can do so after softening the plastic by gently heating with a small flame from a microburner (Fig. 5). Direct the flame for a moment to the outer flat tetrahedral surface to the right, then direct it to the surface to the left; repeat the operations and then heat more strongly on the sharp inside edge, and bend.

The set includes four white plastic balls clearly differentiated in size and further identifiable by one, two, three, or four fine beads running around the equator. Each ball has one hole to fit a rod and another to fit a tube. The substituents in compounds such as CH_3-$CH(OH)CO_2H$, $C_6H_5CHBrCHBrC_6H_5$, $HO_2CCH(OH)$-$CH(OH)CHO$ are clearly differentiated in size and are appropriately represented by balls of corresponding difference in size. The student thus can make models of the lactic acids, the tartaric acids, the aldotetroses. He also can satisfy himself as to the relative stability of different conformations of 1,2-dichloroethane, do conformational analysis on *dl*- and *meso*-stilbene dibromide, etc.

Selection of appropriate balls and use of rubber tubing connectors to form double bonds and C_3–C_4 cycloalkanes permits construction of numerous interesting *cis* and *trans* olefins, optically active allenes, and small ring-compounds—in some of which optical isomerism is superimposed on geometrical isomerism. Models of maleic and fumaric acid in which the substituents on the double bond are represented by large and small balls bring out the greater symmetry of the *trans* isomer and suggest that the *cis* isomer is destabilized by nonbonded interaction between the two large groups. For application of the Cram-Prelog rule of steric control of asymmetric synthesis, balls of three sizes clearly represent large, medium and small groups.

Models which represent a C=C bond by two tetrahedrons joined by rubber connectors and which form a C=O bond by a loop of rubber tubing can be used to present interesting problems. For example, would the



hydrogenation of 9-methyl-Δ^4-octalin (I) be expected to be stereospecific? Yes, the hydrocarbon lies on the catalyst on its flat rear side and hydrogen emerges from the catalyst to attack from the rear and give the 10α-dihydride (II). What is the expected product of borohydride reduction of *trans*-4-keto-9-methyldecalin? The reagent approaches from the less hindered rear side, opens the rear member of the carbonyl group, and gives the 4β-alcohol (IV).

Although considerable chemistry can be studied with merely tetrahedrons, balls, and rubber tubing, the new set includes the following additional pieces: an oxygen atom (red plastic), a nitrogen atom (blue plastic), and an aromatic double bond (corresponding to 1.39 Å), which also serves well enough for isolated and conjugated double bonds. In the interest of economy the oxygen and nitrogen atoms are cast in the mold for the half-tetrahedron, since the bond angles of 110° and 109° are very close to the tetrahedral angle of 109°28′.

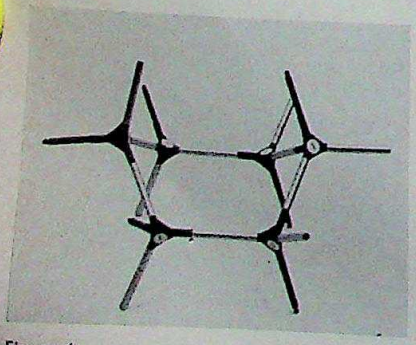


Figure 4a.

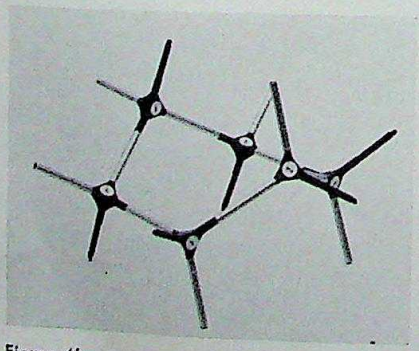


Figure 4b.

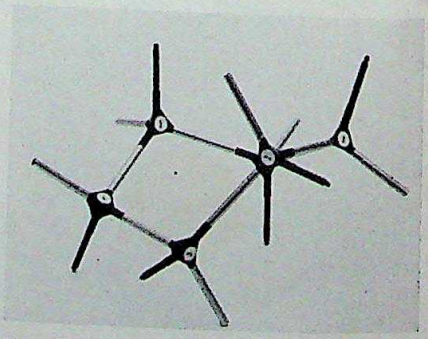


Figure 4

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If an additional oxygen is desired, it can be made easily by painting red the plastic part of a half tetrahedron. A nitrogen atom can be made from an assembled tetrahedron by cutting off one of the bonds carrying a tube and painting the plastic blue. The double bond piece has the correct trigonal carbon angle of 120° and serves nicely for forming benzene rings. The need for two specially molded parts adds to the cost of this piece, but it has the advantage over conventional double bonds in having two rods to connect the carbon atoms. By using wire-cutting pliers to cut a double bond in half, one can produce two carbonyl groups.

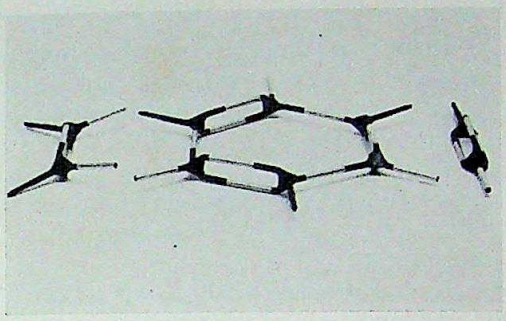

Figure 6.

In case a few double bonds are required, other than those using rubber connectors, a dexterous member of the group can make them by applying the heating and bending technique described above for the production of C_3 and C_4 cycloalkanes; the result is shown in Figure 6 at the left. The model of acetylene (right) was made the same way. The model representing one resonance structure of benzene was made from three double bonds after spreading the remaining bonds from the tetrahedral angle (109° 28′) to the trigonal angle (120°). After forming the ring, the peripheral C—H bonds were straightened.[1]

Development

What has been described is the result of a non-profit project supported by a grant from the NSF. Funds from this source cannot be used for the purchase of production molds and tools, but they have been very useful in meeting the cost of experimental molds and tools, for incidental expenses, and for informing teachers of the progress of the project and seeking evaluation and guidance.[2] Morningstar Corporation undertook to copy in plastic the stainless steel model invented by André Dreiding—manufactured by W. Büchi, Glasapparatefabrik, Flawil, Switzerland, under Dreiding's U. S. patent of 1961, and currently sold in the U. S. for $0.95 per tetrahedron. Gregory Mathus of Morningstar designed the plastic Dreiding model described above. This model embodies the principle, covered by a claim in the Dreiding patent, of forming a C—C bond by sliding of appropriate sections of two C—H bonds, and Mathus has applied for a patent covering the additional invention of his design.

The first plastic pieces were turned out with an experimental one-cavity mold. The first tubes were stamped out of sheet aluminum, since this process would lead to a lower production cost than use of predrawn tubing. The assembled tetrahedron seemed very promising, particularly since the estimated production cost was under 10 cents, and samples were sent for evaluation to 556 universities and colleges. The experimental mold wore out before requests for samples from some 130 additional colleges and high schools could be met, but production models will be supplied to these schools later as samples. Evaluation of the models and estimates of the volume of sale from colleagues were very helpful. The first samples had faults which were easily corrected: weak stamped tubes were replaced by strong predrawn tubes; brittle polystyrene was replaced by a stronger, more elastic formulation; the fit of rod to tube was made snugger; the balls were adjusted to easily differentiated sizes. Everyone agreed that low-cost plastic models would open up a vast student market not touched by the 95 cent models and that they would not interfere with the use of the precise, many-piece Büchi models in research. A point of particular importance stressed by many commentators was that the models would be purchased widely by students at all levels only if the price could be kept low, about $2 for a set sufficient for a beginner in organic chemistry.

Distribution

The cost of production did not preclude meeting this goal and a reasonable royalty agreement could be expected. The cost of production molds and tools was met by drawing on a special annual grant from Research Corporation in support of personal research and projects. There remained the markup to a retailer. Ordinarily a distributor sets as his list price a figure about twice the cost of the item to him and thus is able to meet the cost of handling and advertising as well as realize a modest profit. In the college field the models require little advertising because of the distribution of samples noted above. Further saving will be achieved by offering all pieces in lots of 100 only. For the benefit of those who want to achieve all possible economy, tetrahedrons will be offered uncemented (but with the tubes attached) at a special price. The student needs only to apply methyl ethyl ketone to the two surfaces with a paint brush and press them together for a full 30 sec. A further discount will be allowed on orders accompanied by cash. Student clubs or societies may serve as order-takers.

To promote use of the models in high schools, I have written a small book entitled "Chemistry in Three Dimensions." It presupposes no previous knowledge of chemistry and develops principles of the structure and stereochemistry of organic compounds largely by prompting the student to discover these principles by study of models of his own construction.

[1] The models shown in Figures 5 and 6 were made by David H. Sachs, a Harvard senior.

[2] Preliminary announcement was made in THIS JOURNAL, 40, 62 (1963). A steady stream of requests indicates interest in all parts of the world.

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Edward L. Haenisch
Wabash College
Crawfordsville, Indiana

A Decade of Unusual Progress

The years 1953 to 1963 have been an exciting decade. They have been years of unusually rapid progress in science education and in chemical education in particular. It has been my privilege and honor to have shared this excitement and development with many who will hear or read these words. I deeply appreciate the many wonderful friendships that have arisen during the decade.

Let us look back to ten years ago. The National Science Foundation was only several years old. The first summer institutes in chemistry were yet to be held. There were no visiting scientists programs, no secondary school curricular studies like CHEMS or CBA. The Advanced Placement Program was in its infancy.

I would like to review some of the developments which have occurred in this decade. Let me apologize for what I will miss during my review and for omitting the names of some of those to whom credit is due for the attainments I will describe. I would like also to indulge in a little "crystal ball gazing" for the decade 1963 to 1973.

Let us start with the place of chemical education in the affairs of The American Chemical Society. In 1953 the educational work of the Society's headquarters was handled on a part-time basis by Dr. B. R. Stanerson. He was followed by the first full-time Education Secretary, Dr. Robert Henze. In turn, as these gentlemen have moved higher in the affairs of the Society, that post is now occupied by Robert Silber, but Dr. Stanerson and Dr. Henze continue actively to participate in educational work. Chemical education plays a major role in each of the administrative bodies of the Society. The Board of Directors has its Committee on Education and Students. The Council has its Committee on Chemical Education as well as the Committee on Professional Training. There are other committees of both groups indirectly associated with the work in education. In fact it takes the rather extensive organizational chart shown here to explain the interrelationships. There is an Education Liaison and Advisory Panel which coordinates the multitudinous activities. In fact, the solid and dotted lines of this chart almost proved to be a source of utter confusion for a distinguished member of the Committee on Professional Training at one of its sessions at this Los Angeles meeting.

The stature and prestige of the Division of Chemical Education has increased immeasurably. I was Chairman of the Division in 1947. What went on in those days was child's play to administer in comparison to the task which the present Chairman, Dr. Edward Fuller, faces. The operation of the Division has become so complex that it took a five-day conference at an isolated ranch in Texas in early 1962 to restudy the policies and operation of the Division. The immediate past Chairmen, John Baxter and Carroll King, were largely responsible for the success of this conference.

The JOURNAL OF CHEMICAL EDUCATION has been brought to a position of prominence and usefulness by Norris W. Rakestraw. Under its present Editor, William F. Kieffer, the JOURNAL has achieved heights of greater excellence and has markedly increased the size of the audience which it so well serves.

One of the great developments of this decade has been the concept of "togetherness"—people interested in chemical education, from the top university research scientists to the teachers of science in the elementary grades, including the college and university professors and the high school teachers, have learned to work together cooperatively and productively. Today each has his voice and makes his contribution to the affairs of chemical education as they are worked on together by all of these people. This idea of working together had its early beginnings back in the workshops and in the examinations committees developed by a former winner of the SAMA award in chemical education, Otto M. Smith. These were followed by the Advanced Placement Program conferences, and the NSF institutes. The Chemical Education Material Study and the Chemical Bond Approach Project are examples of the complete cooperation between teachers and scientists at all levels.

This working together has evolved a spirit that must not be lost. As the curricular studies end and as institutes become accepted parts of educational programs, we must take particular caution to see that "togetherness" continues. We must find ways for our teachers and research workers to come together and

The Cover

The 1963 American Chemical Society Award in Chemical Education sponsored by the Laboratory Apparatus aud Optical Sections of the Scientific Apparatus Makers Association was presented to Edward L. Haenisch, Professor and Chairman of the chemistry department of Wabash College at the 144th Meeting of the ACS, Los Angeles, California, April 1963. The award address published here was a feature of the banquet meeting of the Division of Chemical Education held at the University of Southern California on April 2.

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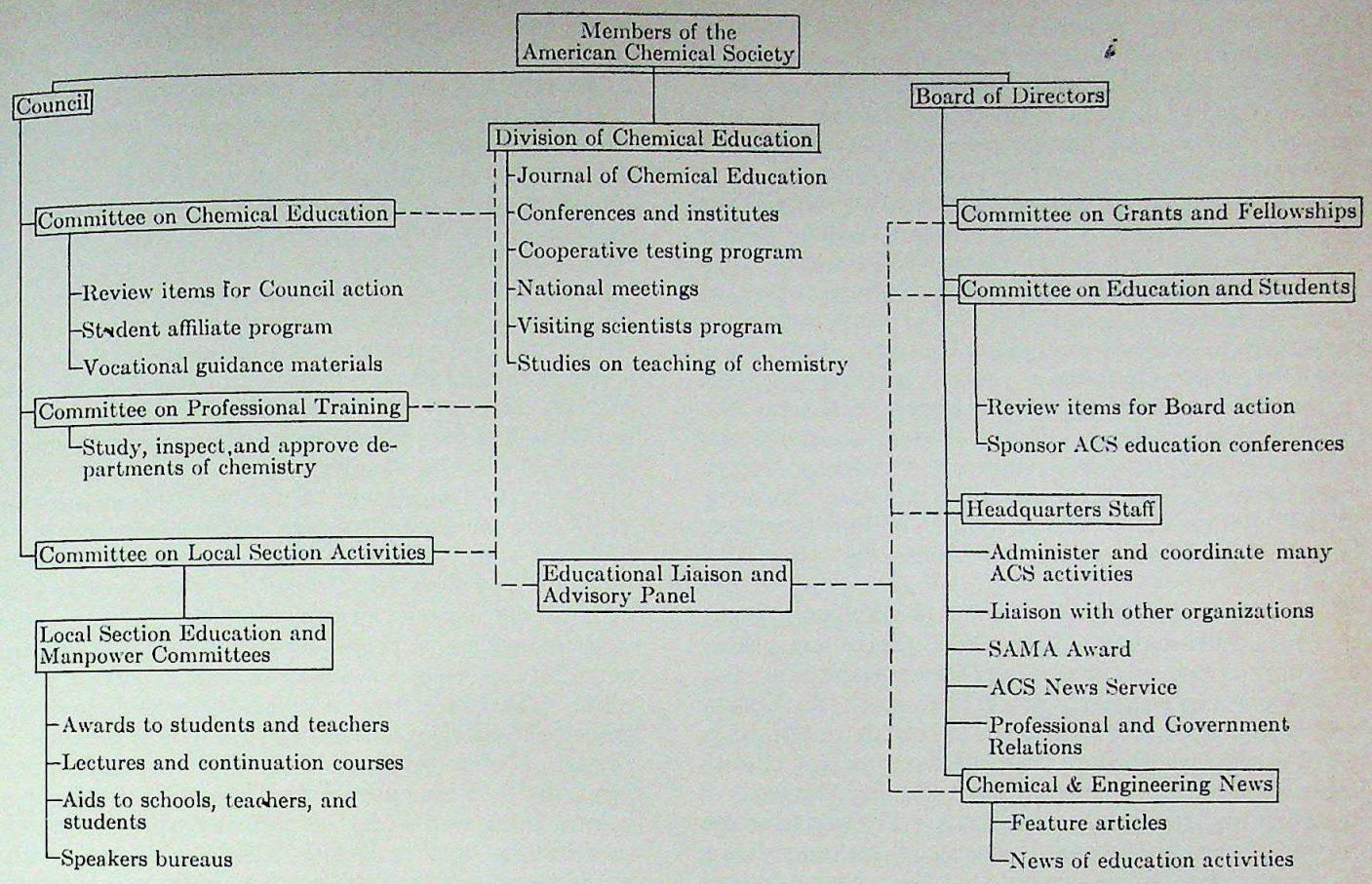

to continue to discuss and to develop matters in the way they have done in the last few years. Preserving "togetherness" is a problem in which we must all take an interest.

In this decade there have been two major sources which have played predominant roles in the support and development of chemical education.

Advanced Placement Program

One of these has been the Advanced Placement Program. This started in 1952 as the School and College Study for Admission with Advanced Standing. Supported by the Ford Foundation, this group wanted to study the effect and stimulation on secondary school science programs of teaching college-level science courses in the high schools and then to go on to see that by some means the colleges recognized these courses and granted advanced standing if not grade and credit. The early program was so successful that it was taken over by the College Entrance Examination Board and has continued to flourish and expand. I can remember that the first examination given by the School and College Study involved less than 300 papers. By 1955, 104 schools and 130 colleges were participating. Over 2000 examinations were taken by somewhat over 1200 students. In 1961 there were over 1100 schools, over 600 colleges, and nearly 18,000 examinations taken by somewhat more than 13,000 students. Today a number of students from excellent high schools find themselves essentially entering college with sophomore standing.

From the beginning, the Advanced Placement Program has held each year a conference attended by both college and secondary school teachers. The conference has always promoted understanding and has considered the broader problems of chemical education as well as the specifics of introducing advanced placement chemistry courses into the secondary schools.

NSF Programs

Of course the outstanding source of support has been the NSF. The Foundation was founded by an Act of Congress in 1950. Its earliest budgets were less than a million dollars. In 1963 the Foundation's budget is 326 million dollars, and nearly 600 million is being requested for fiscal 1964. Under the leadership of its first Director, Allan T. Waterman, who retired this July, the Foundation has developed programs which have had the confidence of all American scientists. In the area of education, the programs have been envisioned and directed by such leaders as Harry C. Kelly and Bowen C. Dees. In fact, the Foundation has become so much a part of our thinking in this decade that we are apt to forget that it is just a little more than ten years old.

There are three programs supported by the Foundation to which I want to refer.

First are the Institutes and Conferences. What changes there have been from those 10-day workshops in Stillwater, Oklahoma, supported on a shoestring budget through the efforts of Otto Smith to the present program of hundreds of institutes and conferences—

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summer, academic, and in-service—with participants' and institutional support furnished completely by the Foundation. I am proud of the role that chemists have played in the development of the institutes program of NSF. J. Arthur Campbell, William Cook, Grant Smith, Robbin Anderson, William Morrell, Harold Iddles, and I have been involved in the development of the program.

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Secondly is the Program of Visiting Scientists. The chemistry part of this program began in 1956 when a committee of which I was Chairman arranged a few dozen visits to colleges. Today the program has become tripartite in nature. Over 150 visits a year are arranged to colleges and junior colleges. Now there are more than 50 visits a year to secondary schools arranged in cooperation with the local sections of the Society, along with a program whereby several dozen visits are made to colleges and universities by foreign visiting scientists. Full support has come from the NSF. Other Chairmen of the Visiting Scientists Committee have been Samuel Massie and Donald J. Cook.

The third program has been the Foundation support for the development of new high school courses in chemistry. We are all aware of the excellent materials that have been produced by CHEMS and CBA. Both of these groups will have their materials published in hard-cover form this fall. In the development of both projects there have been involved literally hundreds of teachers and thousands of students. The participation in the course development by some of our outstanding research chemists has insured that these courses reflect the modern pathways that chemistry is following. Much of the traditional has had to be abandoned.

That these courses have a rather rapid impact on secondary school education is evidenced by the reception given to the physics course produced by the Physical Science Study Committee. This Committee began its operations in 1956 and produced its hard-cover materials in the public domain by September, 1961. It has been estimated that roughly 30% of the high school students studying physics in our country during 1962–3 have taken the course developed by PSSC.

It has been my privilege to have been associated with CHEMS since its inception. The work that I have done on this course has been one of the most exciting and interesting periods of my professional career. It has had a remarkable effect on my college teaching. I am sure that all the others who have participated in these courses can say the same thing. What I hope now is that we will not spend our time arguing as to the relative merits of either course. They are both excellent but different in their approach to exciting high school students to study chemistry and to realize that chemistry is an ever-expanding science. What we should all do is to work together to get as many teachers as we possibly can interested in either or both of these courses.

ACS Committee on Professional Training

Let us turn now from these major projects supported by the NSF to an activity of the ACS which has had a profound influence on chemical education at the collegiate level. I refer to the Committee on Professional Training in whose affairs it has been my privilege to participate for a number of years. This Committee has done much to contribute to the prestige and growth of chemistry departments in our colleges and universities.

Recently in view of the major improvements that are being made in the instruction in mathematics and the sciences at the high school level, and in recognition of the important role played by physical chemistry in the training of the chemist, the Committee on Professional Training has revised and upgraded its minimum standards for the education of a chemist at the baccalaureate level. Included now are semester courses in analytical chemistry and inorganic chemistry which require physical chemistry as a prerequisite along with a year of further advanced chemistry based for the most part on physical chemistry. More emphasis is being placed on the part played by mathematics and physics in the training of a chemist.

At the Awards dinner at this meeting a long-time member of the Committee and last year's winner of the SAMA Award, William G. Young, spoke on the current problems faced by the Committee. Among them he included the concern for junior colleges. The function of these colleges in preparing transfer students to universities and senior colleges is one of their smaller roles. The Committee is currently considering what these colleges should do about training a professional person as what might be termed a "research experimentalist." These people would be trained to become helpful hands in research laboratories, able to carry out preparations and analyses. The Committee is also quite disturbed about the problem of the mushrooming number of graduate schools and the effect on the quality of future doctoral candidates in chemistry.

Advisory Council on College Chemistry

Now let us look at several activities that have just barely started in the decade which I am describing. They will serve as a transition to some of my predictions about the future. These activities are the result of the completion of the secondary school courses in science. At present NSF is supporting investigations into what can be done at the college-university level and at the elementary-junior high school level.

For the college-university level of chemistry teaching, the sponsoring organization is the Advisory Council on College Chemistry under the chairmanship of Charles C. Price of the University of Pennsylvania. The first official meeting of the Council just occurred last month. The Council has no intention of establishing any standardized national programs. Rather it hopes to solicit and collect information and to disseminate as widely as possible summaries of its studies. The Council will immediately start the preparation of a series of "resource letters." These will provide college chemistry teachers with sources of information on concepts and developments likely to be useful in the teaching of modern general chemistry. Among the subjects on which letters have been planned are bond energies, energy absorption at the molecular level, inorganic reaction mechanisms, entropy and statistical mechanics, ligand field theory, and inert gas compounds. The Council also expects to prepare a directory of recommended films and to establish a mechanism for keeping

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the directory current. The same would also identify areas of course content where film presentation would improve teaching and would encourage the production of such films.

The Council expects initially to operate through a series of panels which will hold several-day sessions. Panels are scheduled on general chemistry, the curriculum and advanced courses, teaching aids, and teacher improvement. Each panel expects to prepare definite reports and to circulate the information to all departments of chemistry.

Pre-High School Science

Work is also starting on preparation of materials for the teaching of science in the elementary grades and in junior high school. It is at this level that I feel much effort must be exerted to prevent what is usually dogmatic and uninteresting science teaching. I vividly remember the day that my daughter came home from sixth grade, and to make dinner-table conversation asked me, "Daddy, do you know that there are three isotopes of hydrogen?" I told here that I was well aware of this piece of information and asked her, "What is an isotope?" Her reply, "I don't know."

A similar experience happened to a colleague of mine while I was working for the NSF in 1958–9. His son came home one night muttering something about 2–8–16–32.—In response to his father's query as to what these numbers represented, the son replied that they were the numbers related to the lengths of periods in the periodic table. His father asked him if the numbers shouldn't be 2–8–18–32. The son said that was not what his teacher had said. Returning to school the next day, the boy asked the teacher about 2–8–18–32 as contrasted to 2–8–16–32. The teacher immediately wanted to know who had told the boy those numbers. The young man said his father, and indicated that his father was professor of physics at a well-known eastern institution. The teacher replied that in spite of what his father had said, that he would continue to teach 2–8–16–32 because that was so much easier to memorize.

Actually a number of groups are already at work on this problem. One in which I have recently been invited to participate is under the leadership of the American Association for the Advancement of Science. It will sponsor an eight-week crash writing session at Stanford University this summer. It is hoped to prepare some materials for kindergarten through the third grade.

Let me tell you of some of my experiences as I sat with this group in Washington a few weeks ago. The subcommittee that I joined was discussing measurement. We soon decided that the emphasis should be put on the quantity to be measured rather than on the system of units employed and their conversion. We also decided that the metric system should be introduced early and shown to be as natural and better than the English system.

One of the group envisioned using the familiar "pin the tail on the donkey" game to bring out some of these ideas. The teacher would demonstrate to the students that she could pin the tail on perfectly each time. Before she was blindfolded she would go to the corner of the room and count off the number of steps until she was opposite the place where the donkey's tail belonged. Then she would measure on her body the place where the tail should be pinned on. Then blindfolded she could always put the tail in the right place. She would make quite a point of counting the number of steps from the corner of the room to the donkey. It was hoped that the students in attempting to follow her lead would also count steps but find very shortly that their unit of measurement, their step, was not the same as hers. The game could also be extended to the early introduction to the notion of a coordinate grid.

In this same group we got to arguing as to how the concept of volume ought to be introduced. Should it be developed from length through area to volume, or should it be introduced as a separate concept? We finally decided that the latter was more desirable and again indicated that arbitrary units should be introduced, such as one iced-tea glass as against one juice glass.

Another group that is active in this elementary science field is under the sponsorship of Educational Services Incorporated. I have recently looked at one of their early experiments entitled "Mystery Powders—An Introduction to Analytical Chemistry." The six powders involved are starch, baking soda, powdered sugar, boric acid, plaster of Paris, and a combination of the latter two. The students are led through various methods of identification such as testing with water, heat, iodine, vinegar, and litmus. Ultimately they are able to devise a method of analysis for a mixture.

International Education

Another development of the coming decade will be that of international cooperation. We need to become cognizant of the educational systems of other developed countries such as those in Continental Europe and to help the newly developing countries such as those perhaps in Africa, evolve an educational system of their own. We can help them with our curricular studies, but we must realize that these have to be adapted to the circumstances of the other countries. Recently a Congolese student came to Wabash College, and one of the questions asked of him on a test concerned a diver doing sommersaults and straightening out before he entered the swimming pool. The question, of course, had to do with angular momentum. This poor student didn't know anything about either a diver or a swimming pool.

Much of this international work will be done with the aid of UNESCO in cooperation with the International Unions. At Christmas time I attended an ad hoc Committee of the International Union of Pure and Applied Chemistry at Basel, Switzerland. This Committee recommended that in view of the situation ahead IUPAC should establish a committee on chemical education. It remains to be seen whether the Union takes this step. Recently the ACS organized its Committee on International Activities.

Future Trends

Much emphasis is being placed today on laboratory work which involves quantitative measurements. This is a highly desirable trend, but I still feel that there

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is much to be learned from the interpretation of visual observations on simple test-tube experiments. Particularly is this type of observation valuable if the student is looking at something about which he has not already read a description in his textbook. As an example, let me describe a situation in which I place my own students. To study amphoterism and complex-ion formation we start out by studying what happens when sodium hydroxide is added initially dropwise and ultimately in excess to a solution containing the aluminum ion. Attention is given to the concentration and volume of the aluminum solution used as well as to the number of drops of known molarity hydroxide solution which has been added when precipitation and then solution occur. We then try ammonia instead of sodium hydroxide. We substitute cadmium ion for aluminum ion and try both reagents. Finally we use zinc ion with both reagents. We have studied an example of amphoterism, an example of complex-ion formation, and an example in which an ion is both amphorteric and a complex-ion former. These cases are relatively simple. I then provide the student with a long list of ions which they are to test by using Mn(II) ion, Hg(II) ion in the presence of chloride ion, Hg(II) ion in the presence of nitrate ion, among others. You will recognize that many of these cases present unusual situations. For example, the darkening of the precipitate formed when Mn(II) and hydroxide ions are mixed presents a new problem. The difference in reaction between mercury(II) ion and ammonia in the presence of chloride and nitrate ions is unusual. All of these present problems to the students, who get unexpected observations and must interpret them. Finding the answers to some of the interpretations even requires special library work. I hope that this type of observational laboratory experiment will not become completely lost in the rush toward quantitative measurement. Descriptive chemistry is still an important part of chemical training.

Post-laboratory discussion is most important. The necessity for this has been reemphasized by our experience with CHEM Study. Much is gained by pitting one observer against another, and by seeking possible explanations from members of the group. For my college classes I find it highly desirable to let the laboratory get far ahead of the lecture discussion. The students are then forced to so some genuine thinking to interpret their laboratory observations.

During this past decade we have seen astounding results arising from interdisciplinary research projects—applications of nuclear energy, space science, biochemistry, biophysics, to mention a few. Why should we not let this interdisciplinary notion extend to our teaching? Perhaps the most important development from this viewpoint will come in the construction of the materials for science teaching in the elementary grades and junior high school.

For a number of years at Wabash College we have not taught general chemistry or general physics. We have offered an integrated course on the fundamental principles of physics and chemistry. The early results of this have been previously reported.[1] We are now convinced that this is a very satisfactory way to begin the training of our majors in both physics and chemistry, as well as that of our service students, including the pre-medical ones. I would hope that the decade ahead would see many more experiments in integration of science teaching at the college and university level.

Another area for experimentation lies in the order in which the individual sciences are presented in high school. Experiments along these lines ought to be tried. The natural order is physics, chemistry and finally, biology—the exact reverse of what is now traditional. Certainly modern structural chemistry cannot be understood without a background in physics; molecular biology requires training in chemistry. Why should not the ninth grade course be an introduction to the fundamentals of physics? The course would perhaps not be as sophisticated as the present twelfth-grade one, but it could include the fundamental principles and introduce within the course the necessary mathematical concepts. Tenth grade would be chemistry; eleventh grade would be modern biology. I would suggest that the twelfth grade be a sophisticated high-level course in one of the sciences which might meet the advanced placement requirements for a college-level course.

Let me conclude by telling a story which happened on our campus a month or so ago. The janitor was cleaning off what appeared to be a terrifying mess of mathematical equations from the board in the chemistry lecture room. He turned to me and asked, "Why is it possible that you can teach these students so much these days? It looks like you go far beyond what I thought was possible when I was back in school." I said to him, "Homer, it is because we have achieved a deeper understanding of the behavior of nature. It is no longer a process of pure memorization of fact." I hope that in the decade ahead we will emphasize more wisely and carefully than we have in the past, a measure of the understanding that we have indeed achieved.

[1] E. L. Haenisch and L. S. Salter, this Journal, 35, 246 (1958).

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Polymerization Kinetics and Viscometric Characterization of Polystyrene

A physical chemistry experiment

It would appear from the recent symposium on colloid and surface chemistry (*1*) that this field receives insufficient emphasis in many university chemistry courses. Although it is not contended that the following list is complete, the main source material for practical courses on colloids consists of short chapters in each of three texts on experimental physical chemistry (*2*), a viscosity experiment (*3*), and two texts concerned with the preparation of polymers and a practical course in polymer chemistry (*4*).

In order to broaden the range of experiments available on the physical chemistry of colloids an experiment was devised which proved suitable for use by our final year undergraduate students. In this experiment the rate of polymerization of styrene is measured by two different methods, and the molecular weight of the polystyrene determined by viscometry. Emphasis is placed throughout on the kinetics of the process, but at the same time the student becomes familiar with vacuum techniques, dilatometry, and viscometry.

Theoretical

A simplified kinetic analysis for the radical chain process which involves initiation, propagation, and termination of chains leads to the following equation (*5*)

$$R = k_p k_t^{-1/2}[\mathrm{M}]R_i^{1/2} \qquad (1)$$

where

R = rate of the reaction (rate of consumption of monomer),
R_i = rate of initiation,
$[\mathrm{M}]$ = concentration of monomer,
k_p, k_t = rate constants for propagation and termination reactions respectively.

The initiation process by a chemical initiator such as 2,2′-azobisisobutyronitrile occurs in two stages, the first of which involves the first order decomposition of the initiator into radicals as follows:

$$(\mathrm{CH_3})_2\mathrm{C(CN)\cdot N{:}N\cdot C(CH_3)_2\cdot CN} \rightarrow 2(\mathrm{CH_3})_2\mathrm{C(CN)}\cdot + \mathrm{N_2}$$

The second stage consists of the reaction of monomer with a definite percentage of the isobutyronitrile radicals (known as the percentage efficiency of the initiator), to initiate the polymerization process (*6, 7*). The rate of this stage equals R_i. For a particular system in which the monomer concentration and temperature are constant, the efficiency of initiation is also a constant and is given by the following equation:

$$\text{efficiency} = \frac{R_i}{nk_d[\text{init}]}$$

where k_d is the rate constant for decomposition of the initiator and n is the number of radicals produced from each molecule of initiator. Since k_d and n are both constants, it is clear from the equation that the rate of initiation R_i is proportional to the concentration of initiator [init]. Under these conditions equation (1) reduces to

$$R = \text{constant } [\text{init}]^{1/2} \qquad (2)$$

In the absence of transfer reactions and assuming that termination of chains occurs by disproportionation, the average degree of polymerization, $\bar{P}$ (defined as the average number of monomer units per polymer molecule) is given by the equation

$$\bar{P} = \text{rate of reaction/rate of formation of polymer molecules} = k_p[\mathrm{M}][\mathrm{P}\cdot]/k_t[P\cdot]^2 \qquad (3)$$

In equation (3)

$$[P\cdot] = \sum_{i=1}^{i=n}[P_i\cdot],$$

where $[P_i\cdot]$ is the radical concentration of the ith species (*5*). Under stationary state conditions the rate of initiation R_i equals the rate of termination of chains ($k_t\,[P\cdot]^2$) and substitution for $[P\cdot]$ in equation (3) gives

$$\bar{P} = k_p[\mathrm{M}]k_t^{-1/2}R_i^{-1/2} \qquad (4)$$

Since R_i = constant [init] under the conditions outlined above and the average molecular weight $\bar{M} = \bar{P}\,m$, where m equals the weight of the monomer unit, it is clear that

$$\bar{M} = \text{constant } [\text{init}]^{-1/2} \qquad (5)$$

The average molecular weight $\bar{M}$ of the polymer is related to the intrinsic viscosity or limiting viscosity number $[\eta]$ by the empirical equation

$$[\eta] = K\bar{M}^{\alpha} \qquad (6)$$

in which the values of K and α are constants for a particular polymer, solvent and temperature and have been determined for polystyrene in a number of different solvents (*8, 9*).

Determination of the rate of reaction R for the bulk polymerization of styrene at two or more different initiator concentrations allows a check to be made of equation (2). Measurement of $[\eta]$ in a suitable solvent allows the calculation of $\bar{M}$ for each sample of polystyrene by equation (6) and thus equation (5) can be checked.

The Experiment

Materials. Styrene, laboratory grade, was washed five times with 10% NaOH to remove inhibitor (usually

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quinone), five times with distilled water, and for 24 hr over $CaCl_2$. The product was distilled in an atmosphere of nitrogen at 14 mm Hg pressure and the middle fraction collected. The initiator, 2,2′-azobisisobutyronitrile (Eastman Kodak laboratory grade), mp 100°, was used without further purification, although recrystallization from alcohol at 50° (*6*) may have resulted in better kinetic results (Fig. 1).

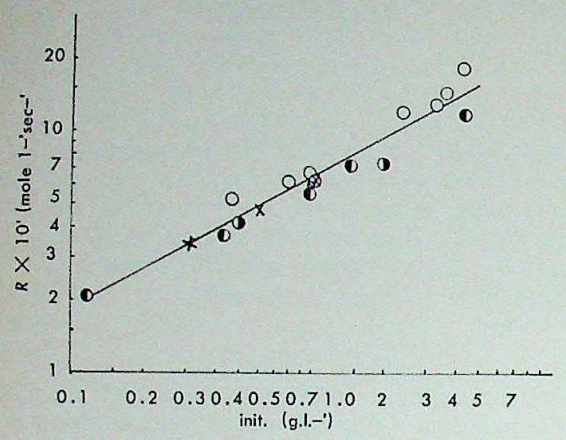

Figure 1. Graph of $R \times 10^4$ versus [init] showing results of students and author (○), (◐) (*10*), (×) (*11*), (○) (*12*), and (I) (*13*).

Apparatus. The vacuum line consisted of a rotary oil backing pump connected to a mercury diffusion pump, a vapor trap cooled in a Dewar flask of liquid air and three outlets fitted with B14 sockets which could be isolated from each other and from the vapor trap and pumps by closing high vacuum stopcocks. The pressure in the system was measured by an Edwards "Vacustat," Model 2G, situated between the diffusion pump and the vapor trap. A Pirani gauge was also available in order to familiarize the students with its use.

Each dilatometer consisted of a 5 ml capacity bulb, a 12 cm length of precision bore capillary tubing[1] of 0.250 cm internal diameter, and a B14 cone for attachment to the vacuum line. A small mark was made on the capillary just above the bulb and the volume up to this mark was obtained by weighing before and after filling with distilled water. The capacity of the capillary tubing in ml per cm length was also checked by filling a 10 cm length with distilled water.

A suspended level, dilution viscometer fitted with a capillary of 0.40 mm internal diameter and capacity of 40 ml was obtained from Polymer Consultants, 3 Fox Court, London, E.C.1., and used for determination of the limiting viscosity number.

Methods. To the bulb of a clean, dry, dilatometer was added by means of a syringe 0.1 ml of a solution of initiator in benzene (50 g/1000 g solution), the exact amount of initiator being obtained by weighing the dilatometer before and after addition of the solution. The benzene was evaporated in vacuo. A graduated tube, made from a Pyrex graduated pipet and fitted with a B14 cone, was filled with about 13 ml of styrene and connected to another outlet of the vacuum line. All joints and stopcocks were lubricated with Dow Corning silicone grease. The styrene was frozen by immersion of the tube in liquid air contained in a Dewar flask, after which it was connected to the vapor trap and pumping system and evacuated to 10^{-4} mm Hg pressure. The stopcock to the vapor trap was then closed and the tube immersed in a beaker of water until the styrene melted. The styrene was again frozen in liquid air and the gas pumped off as before. This cycling process was repeated three or four times until the styrene was thoroughly outgassed. The liquid styrene was then connected to the pumps and about 0.5 ml of forerun distilled into the vapor trap. The stopcock to the pumps was then closed, the volume of styrene in the graduated tube recorded and styrene was distilled into the dilatometer, the bulb of which was cooled in liquid air. The distillation required about 1 hr and from time to time it was necessary to check that the vacuum was being maintained; if not, the system was evacuated again by the pumps. Sufficient styrene was distilled so that at room temperature the dilatometer was filled to about the mark on the capillary. The styrene was then frozen and the tube sealed off in vacuo by the demonstrator. A second dilatometer containing about four times as much initiator as the first was prepared and filled with styrene in a similar manner. The dilatometer tubes can be stored in liquid air in a Dewar flask at this stage if necessary.

An alternative procedure, which is simpler and eliminates the slow distillation process, is to add a known volume of the solution of initiator in benzene to a clean vessel and remove the benzene by evaporation at the water pump. A known volume of styrene (>5 ml) is added to dissolve the initiator and the dilatometer filled to the mark on the capillary with the resulting solution. The dilatometer is immediately attached to the vacuum line via the B14 joint, the solution outgassed as already described, and the dilatometer sealed off in vacuo. The disadvantages of this procedure are that the styrene is not subjected to further purification by distillation in vacuo and also there is the possibility of some polymerization occurring during the period when the styrene and initiator are present together at room temperature.

The first dilatometer tube ([init] = 1 g l^{-1}) was transferred to the thermostat bath at 60.0° and the cathetometer focused on the meniscus level which was read (to ±0.001 cm) at 1-min intervals for the first 5 min (after which time thermal expansion was complete) and at 10-min intervals thereafter for about 180 min. The cathetometer reading of the mark on the dilatometer tube was recorded. The polymerization process was then stopped at a known time by removing the dilatometer from the thermostat bath and immersing it in liquid air. The tube was opened at the capillary end, the solution melted and removed from the dilatometer by a syringe. The solution was run slowly into about 300 ml of stirred methanol (reagent grade) and the dilatometer washed twice with benzene which was added to the methanol. The precipitated polystyrene was filtered through a tared, sintered glass crucible and dried to constant weight at 100° (wt of polymer about 0.3 g). The second dilatometer tube ([init] = 4 g l^{-1}) was transferred to the thermostat bath and the meniscus level read at 1-min intervals for 5 min and then at 5-min intervals for about 90 min. The cathetometer reading of the mark on the dilatometer

[1] Ordinary capillary tubing can be used if it is calibrated along its length (ref. (*4b*), p. 32).

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was recorded, and the polystyrene was then precipitated and weighed as already described.

For each polymerization a graph was made of cathetometer reading against time of reaction and the straight line portion of the graph was extrapolated to zero time. From this value, together with the cathetometer reading of the mark on the dilatometer, the volume of the dilatometer up to the mark and the calibration of the capillary, the volume of styrene present at 60° was calculated. The rate of reduction of volume during polymerization (ml sec^{-1}) was obtained from the gradient of the graph. This rate was converted to the rate of polymerization of styrene R (mole l^{-1} sec^{-1}) using the values of 1.1507 and 0.9467 for the specific volumes of styrene and polystyrene (measured in styrene at 60° (*10*)).

Since the monomer concentration decreased by only a few per cent during the polymerization it was clear from equation (1) that R was approximately constant throughout the reaction. This conclusion was confirmed by the linearity of the graph (except for the short heating period of about 3 min duration) of cathetometer reading against time. A second value of R was obtained for each polymerization from the weight of polystyrene produced over a definite period of time.

Viscometry (ref. (*4b*), p. 87). The suspended level, dilution viscometer was cleaned with chromic acid and then washed thoroughly with distilled water, using the water vacuum pump to suck water through the capillary. It was rinsed twice with acetone and hot air, was filtered through glass wool plugs, and was sucked through the viscometer. The latter was mounted in a vertical position in a thermostat bath at 25° and about 10 ml of reagent grade toluene added down the wide tube. The toluene was sucked slowly up the capillary tube and the time recorded, with a stopwatch reading to 0.1 sec, for the liquid meniscus to pass between the two marks on the viscometer. The results were repeated until three readings were obtained covering a range of $\not>0.3$ sec. The mean value was the solvent flow time, t_0 sec. Very variable results are indicative of a solid suspended in the liquid or lodged in the capillary of the viscometer, in which case the cleaning procedure must be repeated and the liquid filtered through a fine, sintered glass filter.

About 0.1 g of the first sample of polystyrene was weighed accurately into a 10 ml standard flask and about 7 ml of toluene added. The flasks were shaken mechanically to dissolve the polymer and the level of liquid made up to the mark with toluene. The viscometer was dried with acetone as described above and 5 ml of the solution added to the viscometer by a pipet. The flow time of the solution t (sec) was obtained as the mean of three measurements. The solution was diluted by successive additions of 2, 5 and 10 ml of toluene, the flow time being determined after each addition. The concentration C of each solution in g/100 ml was calculated and thence the value of η_{sp}/C at each where $\eta_{sp} = (t - t_0)t_0$. A graph of η_{sp}/C versus C was constructed and the value of the limiting viscosity number $[\eta]$ which equals

$$\lim_{C \to 0} \eta_{sp}/C$$

was obtained by extrapolation to infinite dilution. The procedure was repeated with the second sample of polystyrene and another value of $[\eta]$ determined. The molecular weight was determined by equation (6) using values of $K = 1.34 \times 10^{-4}$ and $\alpha = 0.71$ (*8*).

Results and Discussion

The results of experiments by three different students and the author are summarized in Figures 1 and 2, together with values obtained from the literature for comparative purposes. The values of R are the average of those obtained by the two methods of dilatometry and weighing of the polymer. In general, the values obtained by the two methods agree within about ±1%. From the straight line graph shown in Figure 1, a value of 0.55 is obtained for the exponent in equation (2) while the best line (not shown) drawn through the points obtained from the literature gives a value of 0.48. It is noted that the latter points in general fall below those obtained in the present work. A possible explanation of the discrepancy is that we have omitted to purify the initiator.

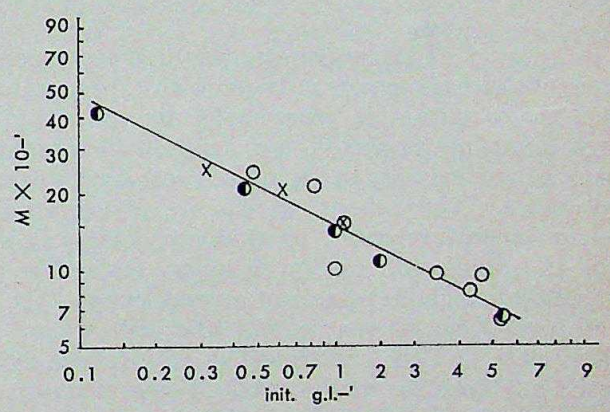

Figure 2. Graph of $M \times 10^{-4}$ versus [init] showing results of students and author (○), (×) (*11*), and (◐) (*13*).

From the straight line graph shown in Figure 2, the value for the exponent in equation (*5*) is calculated to be −0.51 which is in good agreement with the expected value of −0.50.[2] The deviations from the line of points obtained by the students are, as would be expected, somewhat greater than those recorded from the literature. The agreement, however, is adequate to indicate that the experiment is worthwhile. Because of the considerable time required for this experiment (about 32 hr) it is convenient to divide it into two parts, the first of which involves the kinetics of the polymerization process (20 hr) and the second, the molecular weight determination by viscometry (12 hr).

Literature Cited

(1) J. Chem. Educ., 39, 167–202 (1962).
(2) (*a*) Daniels, F., Mathews, J. H., Williams, J. W. Bender, P., and Alberty, R. A., "Experimental Physical Chemistry," 5th ed., McGraw-Hill, New York, 1956; (*b*) Shoemaker, D. P., and Garland, C. W., "Experiments

[2] Combinations of equations (2) and (5) for two polymerizations at different initiator concentrations gives

$$R_1/R_2 = [\text{init}_1]^{1/2}/[\text{init}_2]^{1/2} = \overline{M}_2/\overline{M}_1$$

where the subscripts refer to the two different polymerizations. The students checked their results by this equation.

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in Physical Chemistry," McGraw-Hill, New York, 1962; (c) WILSON, J. M., ET AL., "Experiments in Physical Chemistry," Pergamon Press, Oxford, 1962.
(3) VAN HOLDE, K., AND ALBERTY, R. A., J. CHEM. EDUC., 26, 151 (1949).
(4) (a) SORENSON, W. R., AND CAMPBELL, T. W., "Preparative Methods of Polymer Chemistry," Interscience Publishers, New York 1961; (b) PINNER, S. H., "A Practical Course in Polymer Chemistry," Pergamon Press, New York, 1961.
(5) BURNETT, G. M., "Mechanism of Polymer Reactions," Interscience Publishers, New York, 1954, pp. 98–109.
(6) BEVINGTON, J. C., BRADBURY, J. H., AND BURNETT, G. M., *J. Polymer Sci.*, 12, 469 (1954).
(7) BEVINGTON, J. C., "Radical Polymerization," Academic Press, London, 1961, p. 29.
(8) BAWN, C. E. H., FREEMAN, R. F. J., AND KAMALIDDIN, A. R., *Trans. Farad. Soc.*, 46, 1107 (1950).
(9) BAWN, C. E. H., GRIMLEY, T. B., AND WAJID, M. A., *Trans. Farad. Soc.*, 46, 1112 (1950).
(10) MATHESON, M. S., AUER, E. E., BEVILACQUA, E. B., AND HART, E. J., *J. Am. Chem. Soc.*, 73, 1700 (1951).
(11) BONSALL, E. P., VALENTINE, L., AND MELVILLE, H. W., *J. Polymer Sci.*, 7, 39 (1951).
(12) BRADBURY, J. H., AND MELVILLE, H. W., *Proc. Roy. Soc.*, 222A, 456 (1954).
(13) BAYSAL, B., AND TOBOLSKY, A. V., *J. Polymer Sci.*, 8, 529 (1952).

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Viscometric Determination of the Isoelectric Point of a Protein

This experiment was designed to present students with an opportunity to do an experiment of a *quantitative* nature in macromolecular chemistry, an area commonly neglected in undergraduate laboratory work or studied only by means of short qualitative experiments. The experiment can be performed in a 3-hour laboratory period by students working in pairs and is suitable for use by chemistry majors or premedical students in courses at several levels. The use and operation of viscometers and *p*H meters are illustrated, and the experiment is an excellent test of technique since the results obtained depend very much on manipulative care and cleanliness.

Mobility, conductivity, solubility, osmotic pressure, stability toward coagulating agents, and viscosity of proteins are a minimum at the isoelectric point. The minimum in the case of viscosity is quite sharp and easily detected by preparing protein solutions of various *p*H's, determining the viscosities of these solutions, and graphically finding the *p*H for minimum viscosity.

The structure of proteins, the meaning of the terms zwitterion and isoelectric point, the principle and technique of operation of a *p*H meter, the measurement of viscosity[1] and viscosity units[2] are discussed in advance of the experiment, either in class or in a written introduction to the experiment. The students should be warned of the fragility of the *p*H electrodes, the danger of the electrodes becoming blocked by dried protein solutions, the inadvisability of clamping viscometers across both arms and the absolute necessity for cleanliness. The technique of rinsing and filling viscometers and of measuring viscosities in minimum time should be discussed.

A viscometer of the Ostwald or Cannon-Fenske[3] type with a drain time for water of around 2–3 min is suitable for this experiment. It is convenient to keep the viscometer in a detergent-filled graduate from period to period. The *p*H meter need not be very sensitive; an instrument graduated in 0.1 *p*H unit and capable of a reproducibility of ± 0.02 *p*H unit is adequate. The use of a constant temperature bath at 25°C is advisable, but a stirred large volume of water at 25°C is suitable. A 1% by weight stock gelatin solution ("Knox" unflavored will work very nicely) has been most commonly used by us; it should be prepared the day before to allow it to age to constant viscosity.

The Experiment

Six 0.5% solutions of gelatin of *p*H values approximately every 0.5 *p*H unit from 3.5 through 6.0 are prepared by dilution of an aged 1% gelatin stock solution. This operation is conveniently done by pipetting 50 ml portions of gelatin solution into six 100-ml volumetric flasks, diluting with water to about 20 ml short of the marks, adding dropwise some previously prepared dilute HCl ($pH \cong 1$) until each solution has a *p*H near the desired value and finally diluting to the marks. Some drift in *p*H will be observed and sufficient time

Presented at the eleventh annual meeting of the Pennsylvania Association of College Chemistry Teachers, Dickinson College, Carlisle, Pennsylvania, March, 1962.

[1] DANIELS, F., ET AL., "Experimental Physical Chemistry," 6th ed., McGraw-Hill Book Co., Inc., New York, 1962, pp. 147–57.

[2] JIRGENSONS, B., AND STRAUMANIS, M. E., "A Short Textbook of Colloid Chemistry," John Wiley and Sons, Inc., New York, 1954, pp. 143–4.

[3] CANNON, M. R., AND FENSKE, M. R., *Ind. Eng. Chem., Anal. Ed.*, 10, 297 (1938).

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must be allowed for the electrodes to come to equilibrium with the solutions before reading the *p*H. Some difficulty with foaming may cause trouble in diluting to the mark, but the error is slight.

The times for flow through the capillary of the viscometer at 25°C are measured for water and the six gelatin solutions. Drying of the viscometer with acetone, the usual procedure recommended in texts, is not necessary so long as the viscometer is carefully and thoroughly rinsed with the solution to be used. Drawing the solution up through the capillary into the storage bulb at the top and allowing it to drain down once of its own accord before final measurement usually insures that the solution is at the bath temperature. Large bubbles in the capillary side of the viscometer can usually be avoided by carefully forcing the solution in and out of the capillary.

Results

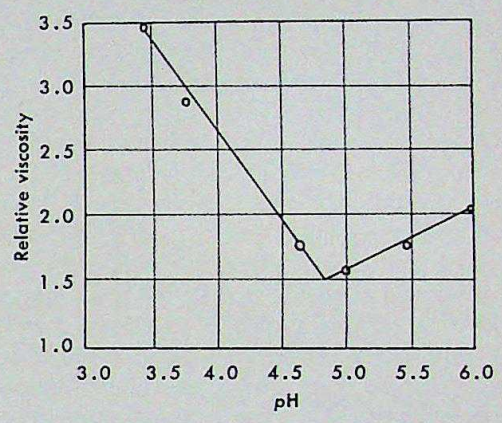
The relative viscosities of the six gelatin solutions are calculated and a plot of relative viscosity versus *p*H prepared. The isoelectric point is determined from the point of intersection of the two nearly linear branches of the plot and is compared with a literature value.[4] The plot diagram presents typical results on a 0.5% gelatin solution at 25°C; the experimentally determined isoelectric point was at *p*H = 4.8, the commonly given literature value being 4.7.[5] Lack of sharpness in the minimum or a large error usually indicates impurities in the protein, dirty glassware, or the presence of fairly large amounts of salts.

[4] Most standard texts on colloid and surface chemistry list the isoelectric points of the more common proteins with references to the original literature.

[5] Abramson, H. A., *J. Gen. Physiol.*, 13, 169 (1930).

Other Applications

With suitable changes in the conditions proteins such as albumins, fibrins, and hemoglobins may be used. Casein is not suitable because of its tendency to precipitate at its isoelectric point. An interesting experiment is the determination of the changes in viscosity of a fresh gelatin solution due to aging. Although viscometry is perhaps the simplest method to use, other methods such as conductance, mobility, and sensitivity toward coagulating agents may be used to determine the isoelectric point. The isoelectric points of purified amino acids[6] may be conveniently determined by conductance or electrophoretic mobility.



The author is indebted to several students for working out details of the experiment and to Professor Charlotte I. Damerel of Wilson College for her helpful suggestions.

[6] Hodgman, C. D., edit, "Handbook of Chemistry and Physics," 38th ed., Chemical Rubber Publishing Co., Cleveland, Ohio, 1956, p. 1649.

A Sobering Experience with Isopropyl Ether Peroxide

In sorting through some bottles of chemicals in a basement storeroom recently we found two $2^1/_2$-l glass-stoppered bottles labeled *Isopropyl Ether—Student Preparation*. Although no date was on the labels, we knew that the bottles had been there for more than twenty years.

Both bottles were nearly a third full of camphor-like crystalline solid beneath the liquid upper layer. Having heard of the tendency for isopropyl ether to form a peroxide, we suspected that the solid might be dangerous although it looked harmless enough. The bottles were taken to the dispensing stockroom, and the supernatant liquid poured down the drain. Water was added but the solid proved to be insoluble. The bottles with their contained water and solid were allowed to stand around several weeks awaiting disposal.

As part of a general stockroom cleanup the bottles were finally loaded into a box along with sundry containers of sodium scraps and unlabeled chemicals and taken by the writer and the stockroom keeper to the dump, located in a marshy area at the edge of town. Still aware that the white solid might be dangerous we tossed one bottle as far as possible out into the bog and the second after it in the hope that both would be broken. Failing in this attempt, we threw stones at the bottles to break them. When the first stone struck, there was a violent explosion which blasted mud and debris over the surrounding landscape. Fortunately, neither the writer nor his assistant were hit by flying glass.

This incident not only points up the danger inherent in old samples of isopropyl ether but also illustrates the hazards which are always present around a chemistry laboratory. Our knowledge that the solid might be dangerous caused us to take measures which ultimately led to the removal of the hazard, but we shudder to think of what might have happened during the period between discovery and disposal—to say nothing of what might have happened as a result of the explosion.

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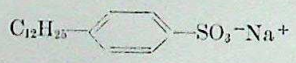
Separation of Surface Active Compounds by Foam Fractionation

Foam fractionation has been used by many investigators to separate mixtures of surface active compounds (*1*). The separations obtained are surprisingly good considering the relatively simple experimental technique and apparatus used. For example, mixtures of two organic dyes, Patent Blue and Scarlet Red, form violet water solutions whose color intensity depends on the relative concentration of the two dyes. However, after passing air for a short time through the solution to create foam, the residual liquid is red and the foam is blue, indicating that most of the Patent Blue dye has been removed from solution and concentrated in the foam phase.

The purpose of this paper is to review briefly the theory of separation by foams and to describe a foam fractionation apparatus, which has been found useful for studing quantitatively the separation of detergents from dilute water solutions. The equipment is not difficult to build or operate and several experiments can be made in 2 or 3 hr. A number of foam fractionation experiments could be profitably incorporated into a laboratory course in analytical or physical chemistry.

A surface active molecule contains a polar end ("head"), which is hydrophilic, and a nonpolar, hydrocarbon end ("tail"), which is hydrophobic. A typical example of a surface active molecule is sodium dodecylbenzenesulfonate.



At gas-liquid interfaces, surface active molecules are adsorbed from solution and orient themselves so that their polar "heads" are predominantly in the liquid phase if it is polar, or only their hydrocarbon "tails" are immersed if the liquid is a nonpolar hydrocarbon. This adsorption and orientation of surface active molecules at an air-water interface occurs because the hydrocarbon end of the molecule has little attraction for polar water molecules and will tend to remove itself from solution by accumulating at the interface (Fig. 1).

The amount of surface active compound adsorbed from solution at an interface can be calculated rigorously using thermodynamics (*2*, *3*). This quantity is given by the Gibbs adsorption isotherm:

$$\Gamma = -\frac{c}{RT}\frac{d\gamma}{dc} \qquad (1)$$

where Γ is the moles of material adsorbed per cm^2 of interface surface, c is the concentration (moles/l) of surface active material in the bulk of the solution, γ is the surface tension (dynes/cm) of the solution, T is the temperature (°K) and R is the gas constant (8.314×10^7 ergs/°K /mole). Actually, the activity of the surface active compound should be used in the above equation, but the concentration, c, is used at low concentrations and it is sufficiently accurate for most calculations. The Gibbs adsorption isotherm indicates that Γ will be positive if the derivative, $d\gamma/dc$, is negative. This means the concentration of material at the gas-liquid interface will be greater than in the bulk of the solution if the material is surface active and decreases the surface tension of water. If a procedure could be devised for skimming off the top surface layers of a solution containing surface active molecules, then most of these surface active molecules could be separated from the bulk of the solution and concentrated in a small volume of liquid. Foam fractionation takes advantage of the surface activity of molecules, such as detergents, by providing a practical means for their separation. By creating large liquid-gas interfacial areas, as exists in foams, and then removing this "foam phase" from the surface of the bulk liquid, good separations of surface active molecules from solutions may be obtained.

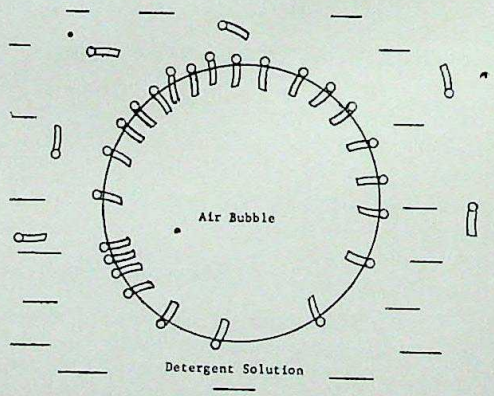


Figure 1. Schematic representation of detergent molecules being adsorbed at gas-liquid interface as air bubble passes through detergent solution. With solutions of sodium dodecylbenzenesulfonate the hydrated polar "heads" represent the $—SO_3Na$ group and the hydrocarbon "tails" represent the $C_6H_4C_{12}H_{25}$ group.

A convenient apparatus for studying the foam fractionation of various solutions is shown in Figure 2. The foam fractionation column is made of glass with a diameter of 2 in. and 3 ft long, although columns of different diameter and length may be used. The column is designed so that the section containing a fritted glass gas disperser, or the column itself, may be replaced. Similarly, the top portion of the column containing foam may be replaced and extensions added to lengthen it. The air supply is metered using a rotameter and saturated with water before being introduced at the bottom of the column. A mercury U-tube is used as a safety valve to prevent excessive

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pressure buildup behind the fritted glass disperser at high aeration rates. A constant temperature jacket is provided to study the effect of altering temperature on foaming. During an experiment the column is filled with a measured volume of liquid to a mark about 6 in. from the top, the solution is aerated and the foam collected overhead. Samples of foamed water may be withdrawn periodically from the bottom of the column for analysis.

Some typical results which were obtained by foaming solutions of sodium dodecylbenzenesulfonate are shown in Table 1. The detergent concentration before foam fractionation varied from 1.5 to 8 ppm and after foam fractionation it was 1 to 2 ppm. The collapsed foam volume accounted at most for only 1 volume per cent of the original liquid foamed. The detergent concentration in the collapsed foam phase may be calculated using a material balance equation:

$$V_O c_O = V_F c_F + V_L c_L \qquad (2)$$

where V refers to liquid volumes and c refers to detergent concentrations. The subscripts O, F, and L refer respectively to the original solution, the collapsed foam and the residual, foamed solution. The three liquid volumes are measured and the concentration of detergent before and after foam fractionation is determined by chemical analysis. The equation then can be solved readily for the one unknown quantity, c_F.

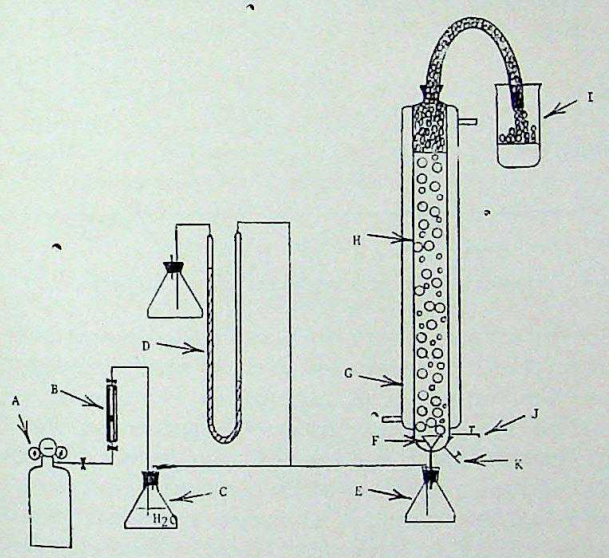

Figure 2. Schematic diagram of foam fractionation equipment: *A*, air cylinder; *B*, gas rotameter; *C*, gas saturator; *D*, mercury U-tube; *E*, liquid trap; *F*, fritted glass gas disperser; *G*, constant temperature water jacket; *H*, foam fractionation column; *I*, foam receiver; *J*, tap for withdrawing foamed solution; *K*, tap for draining foam fractionation column.

Of course, c_F may be obtained by chemical analysis also if a sufficient volume of foam is collected. Calculated values of c_F for the three experiments in Table 1 were 780, 400, and 600 ppm. The removal of detergent may be expressed either as per cent, based on concentrations, or as an enrichment ratio, based on the concentration of detergent in the foam and the residual liquid (*4*).

If chemical analysis for detergents or other surface active molecules is not convenient, then foam stability, foam volume, and surface tension measurements may be used to follow the removal by foam fractionation. The data in Table 1 were obtained using the unfoamed solutions only, but they do indicate how these quantities depend on detergent concentration. Thus, foam stability and foam volume increase with detergent concentration, while surface tension decreases. Hence, foam stability, foam volume, or surface tension may be substituted for chemical analysis in semiquantitative work. For example, calibration curves of surface tension versus detergent concentration may be used to estimate detergent removal by foam fractionation.

Various experiments may be made with this equipment to study the effect of different variables on foam fractionation. Variables which may be explored are: temperature, aeration time, gas bubble size, gas type, *p*H of solutions, concentration and type of surface active molecule, and effect of additives on removal (*5*).

It is interesting to note that foam fractionation is being investigated as a potential purification method of waste water effluents (*6*, *7*).

The author wishes to thank T. D. Searl for help with the analytical work and W. A. Schaefer for constructing the foam fractionation column.

Literature Cited

(1) Bikerman, J. J., "Foams: Theory and Industrial Applications," Reinhold Publishing Corp., New York, **1953**, chap. 10.

(2) Adamson, A. W., "Physical Chemistry of Surfaces," Interscience Publishers, New York, **1960**.

(3) Davies, J. T., and Rideal, E. K., "Interfacial Phenomena," Academic Press, New York, **1961**

(4) Gaden, E. L., and Schnepf, R. W., *J. Biochem. Microbiol. Tech. Eng.*, **1**, 1 (1959).

(5) Karger, B. L., and Rogers, L. B., *Anal. Chem.*, **33**, 1165 (1961).

(6) Klein, S. A., and McGauhey, P. H., *Water Pollution Control Federation Journal*, **35**, 100 (1963).

(7) Eldib, I. A., and Skomoroski, R. M., Renovation of Waste Water by Foam Fractionation, Report to U.S. Public Health Service, Contract No. PH 86-62-26 (1962–3).

Table 1. Typical Results with Foaming Solutions of Sodium Dodecylbenzene Sulfonate

Detergent (ppm) Before foaming	After foaming	Foam collected (ml)	(Vol %)	Detergent removed (%)	Enrichment ratio, C_F/C_L	Foam stability (sec)	Foam volume (ml)	Surface tension at 24°C (dyne/cm)
1.51	0.99	2	0.08	34	789	3	4	67.0
2.43	1.89	4	0.16	22	215	4	5	61.8
8.04	2.07	30	1.0	74	289	330	10	58.3

For this experiment 3 l of distilled water plus detergent—dodecylbenzenesulfonate, commercial grade—was foamed in a 4-in. diameter foam fractionation column at 24°C. The air flow rate was 30×10^2 cc/min (STP) for 3 min. Air was dispersed through a fine fritted glass disc, nominal maximum pore size 4–5.5 microns. The detergent was analyzed by the methylene blue method. Vol % foam collected was calculated on the initial volume of the foamed solution, 3 l. The detergent removed was calculated on the basis of detergent concentrations in solution. C_F/C_L represents concentration of detergent in foam divided by concentration of detergent in residual foamed liquid. The foam stability was measured by hand-shaking 50 ml of unfoamed solution in a stoppered 100 ml graduated cylinder for 30 sec at a uniform rate and observing the time required for the foam to collapse. The foam volume is the maximum observed during the foam stability test. Surface tension was measured with a duNuoy ring tensiometer.

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Freezing Point Observations on Micellar Solutions

In the teaching of phase relationships in elementary chemistry a distinction is generally made between the cooling curve obtained for a pure substance above, at, and below its freezing point and that obtained for a solution from which pure solid separates. In the first case, of course, the temperature remains constant during the entire freezing period, as it must in a one-component, two phase system maintained at constant pressure. In the second case, dealing with a two-component, two-phase system, the system is univariant at constant pressure.[1] Since the composition of the liquid solution is a function of the extent to which solid solvent has separated, the freezing point of such a binary solution is in general a function of time.

In the course of a recent research program we have come across an interesting case of a binary solution from which pure solid solvent separates but whose freezing point is nevertheless not time-dependent. An interesting contrast is provided by *p*-methylphenyl glucose and *p*-butylphenyl glucose, two members of a series of compounds which we have synthesized by the method of Hurd and Bonner.[2] The first of these two compounds does not form micelles in aqueous solutions in concentrations less than 10% by weight, whereas the second forms micelles readily.

If one studies the cooling curves obtained for a variety of aqueous solutions of *p*-methylphenyl glucose one obtains the results shown in Figure 1. These are typical of the time-dependent freezing point results for normal, approximately ideal solutions. Here the equilibrium is one involving pure ice and aqueous solutions of time-dependent concentration. In contrast, the results obtained with *p*-butylphenyl glucose, shown in Figure 2, are time-independent beyond the period of initial supercooling.

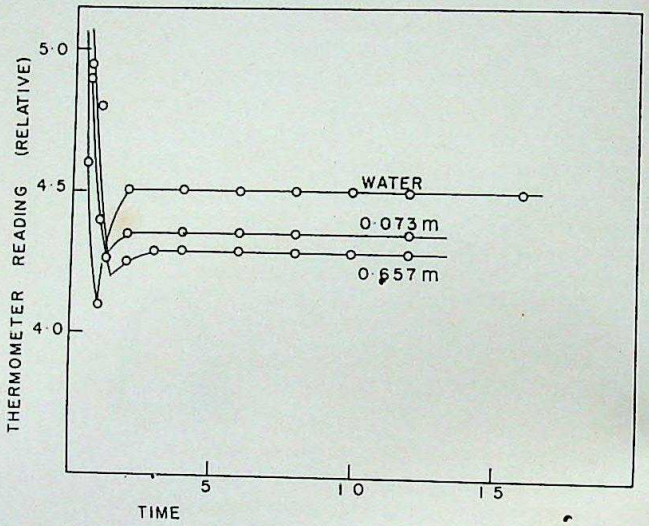

Figure 2. Freezing behavior of *p*-butylphenyl glucose solutions.

The author has shown, in a number of earlier publications,[3] that it is convenient and physically sensible to regard the formation of micelles in solution as the formation of a distinct phase in the system, so that at room temperature a solution of, say, sodium dodecyl sulfate above its critical micelle concentration is a two-phase system consisting of a micellar phase bathed in a solution of single surfactant ions.[3] When such a solution begins to freeze, the system consists of a solution phase, pure solid solvent (ice) and the micellar phase, and at constant pressure it is invariant. The fact that the micellar phase is in the form of small micelles which are probably liquid in structure distinguishes this case from the usual eutectic system in which two *solid* phases are present. Moreover, a micellar solution in which the solute is a non-electrolyte, as in the present case, is distinguishable from one in which the solute is an electrolyte, e.g., sodium octyl sulfate. In this latter case the micelle bears a net electrical charge and the concentration of counterions does change somewhat with the micelle concentration, with the result that in sodium octyl sulfate solutions above the critical concentration the freezing point is time-dependent,[4] though less markedly so than in the case of a simple solute such as sodium chloride.

[1] Daniels, F., and Alberty, R. A., "Physical Chemistry," John Wiley and Sons, Inc. (New York), 1961, p. 244.
[2] Hurd, C. D., and Bonner, W. A., *J. Am. Chem. Soc.*, 67, 1972 (1945).
[3] Hutchinson, E., Inaba, A., and Bailey, L. G., *Zeit. physik. Chem.* (Frankfurt), 5, 344 (1955).

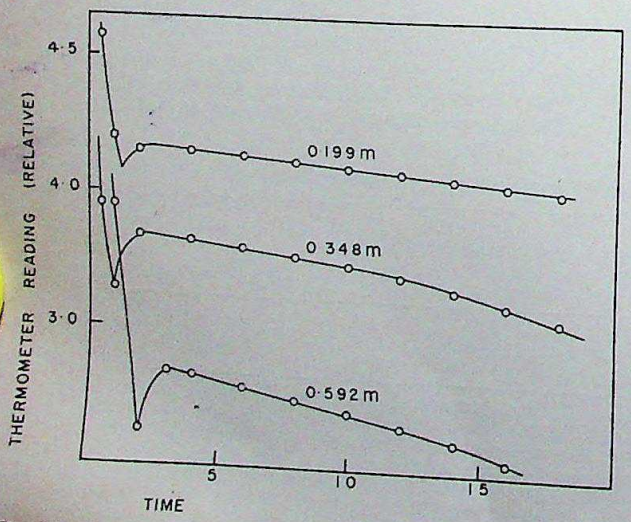

Figure 1. Freezing behavior of *p*-methylphenyl glucose solution.

[4] Bean, K. E., M. S. Dissertation, Stanford University, 1951.

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Textbook Errors, 45

Catalytic Inhibition by Adsorbed Hydrogen

Ammonia may be catalytically decomposed at a temperature of several hundred degrees centigrade according to the equation

$$2NH_3 \rightarrow N_2 + 3H_2$$

Some textbooks of physical chemistry state that the decomposition of ammonia on a platinum catalyst follows the kinetic expression

$$\text{rate} = k_1 p_{NH_3}/p_{H_2}$$

because a product, hydrogen, is strongly adsorbed and inhibits the reaction. Since the early work of Hinshelwood and Burk (*1*), presenting the above results and conclusions, studies in the last few decades have yielded slightly differing exponents in the rate expression which confirm that the rate of decomposition is *inversely* related to some power of the hydrogen pressure. However, they have also established that the reason for the negative exponent is quite different from that stated.[1]

Early researches into the mechanism of ammonia synthesis and decomposition were hampered by experimental factors such as the difficulty of preparing clean and reproducible surfaces and also by the fact, not fully appreciated for some time, that many transition metals form nitrides when treated with ammonia-hydrogen mixtures of high ammonia content. This is known to cause considerable alteration of the decomposition kinetics (*2*) but the Group VIII metals have less tendency to react in this way than those of earlier groups.

There was also a mental barrier arising from the tendency to interpret the observed kinetics solely in terms of the simple Langmuir isotherm and Langmuir-Hinshelwood mechanisms. Thus, Dixon (*3*) reported that in the kinetic expression for the decomposition of ammonia on copper the indexes of the ammonia and hydrogen pressures were both (arithmetically) equal to unity. He readily explained this in a manner similar to that of Hinshelwood. Subsequent analysis of this same data (*4*) showed that neither exponent was integral and that their ratio was 2:3, a fact of considerable significance with respect to later theories.

Langmuir-Hinshelwood Kinetics

By the Langmuir isotherm (*5*), the fraction of the surface sites, θ, occupied by adsorbed molecules of a gas at pressure p is

$$\theta = \frac{cp}{1 + cp}$$

where c is a constant. For the extreme cases of very strong or very weak adsorptions this approximates to $\theta = 1$ on to $\theta = cp$. Extending this to simultaneous adsorption of two gases, A and B at pressures p_A and p_B, the fraction covered by A, θ_A, is given by

$$\theta_A = \frac{ap_A}{1 + ap_A + bp_B}$$

which simplifies to ap_A/bp_B if the adsorption of A is weak and that of B is strong.

The above derivations assume that each adsorbed molecule occupies only one site; but if adsorption is dissociative, as occurs with a diatomic gas such as hydrogen, then the fraction of the surface covered by H atoms, θ_H, has the value

$$\theta_H = \frac{c' p_{H_2}^{1/2}}{1 + c' \, p_{H_2}^{1/2}}$$

and similarly the exponent of the pressure is halved in the other equations. On a catalyst surface almost covered by adsorbed hydrogen atoms, the fraction occupied by ammonia, θ_{NH_3}, would, on this basis, be related to the gaseous concentrations by the expression

$$\theta_{NH_3} \propto p_{NH_3}/p_{H_2}^{1/2}$$

If the velocity of decomposition were determined by this surface concentration then the rate expression should also be of this form, whereas the pressure function quoted is

$$\text{rate} \propto p_{NH_3}/p_{H_2}$$

For these reasons alone a Langmuir-Hinshelwood treatment may be considered quite unsatisfactory as an interpretation of the kinetics of ammonia decomposition.

In 1931 Winter (*6*), who obtained the expression

$$\text{rate} = k_2 p_{NH_3}^{0.9}/p_{H_2}^{1.5}$$

on an iron catalyst, suggested that the reaction occurs by the progressive stripping of hydrogen atoms from the adsorbed ammonia molecules to give adsorbed nitrogen atoms, which occupy most of the surface. He considered the desorption of these strongly-bound adsorbed atoms to be the rate-controlling step, all the other surface processes being in equilibrium.

After Emmett and Brunauer (*7*) had demonstrated the close correspondence between the rate of nitrogen

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Suggestions of material suitable for this column and guest columns suitable for publication directly are eagerly solicited. They should be sent with as many details as possible, and particularly with references to modern textbooks, to Karol J. Mysels, Department of Chemistry, University of Southern California, Los Angeles 7, California.

[1] Since the purpose of this column is to prevent the spread and continuation of errors and not the evaluation of individual texts, the source of errors discussed will not be cited. In order to be presented an error must occur in at least two independent recent standard books.

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adsorption and the rate of ammonia synthesis on a promoted iron catalyst, Temkin and Pyzhev (*8*) presented a detailed theory of the reaction mechanism—later substantiated experimentally (*9*) and theoretically (*10*) by Emmett, Brunauer, and co-workers—which is capable of correlating almost all work on ammonia synthesis or decomposition.

The Temkin Theory

Following Winter, this scheme assumes an equilibrium on the surface of the catalyst.

$$NH_3(g) \rightleftharpoons NH_3(ads) \rightleftharpoons NH_2(ads) + H(ads) \rightleftharpoons NH(ads) + 2H(ads) \rightleftharpoons N(ads) + 3H(ads)$$

also

$$2H(ads) \rightleftharpoons H_2(g)$$

The rate of ammonia decomposition, controlled by the step

$$2N(ads) \rightarrow N_2(g)$$

can be obtained if the fraction of the surface sites occupied by species other than nitrogen atoms is negligibly small and if the equations for nitrogen adsorption are known. These workers postulated that this follows the Temkin isotherm which assumes, unlike the Langmuir isotherm, that as the extent of surface coverage increases, the heat of adsorption decreases and in a linear manner. The equations, which are fair approximations for moderate extents of coverage, are:

$$\text{rate of adsorption} = k_a p\, e^{-g\theta}$$

$$\text{rate of desorption} = k_d e^{h\theta}$$

$$\text{fractional surface coverage, } \theta = \frac{1}{f} \ln a_0 p$$

where k_a, k_d, g, h, f and a_0 are constants.

Clearly, the correct value of θ_N will not be that obtained by substituting in this equation the pressure of nitrogen over the catalyst, because the adsorbed and gaseous nitrogen are not in equilibrium. But, since all adsorbed species are in equilibrium with the other components of the gas phase, the pressure of nitrogen which would be in equilibrium with the surface N atoms can be related to the ambient pressures of ammonia and hydrogen by the equilibrium constant, K, for

$$2NH_3 \rightleftharpoons N_2 + 3H_2$$

This "fictitious pressure," $p_{N_2}{}^*$, is given by

$$p_{N_2}{}^* = K p_{NH_3}{}^2 / p_{H_2}{}^3$$

Thus the fraction of the surface covered by nitrogen atoms,

$$\theta_N = \frac{1}{f} \ln a_0 p_{N_2}{}^*$$

$$= \frac{1}{f} \ln a_0 K p_{NH_3}{}^2 / p_{H_2}{}^3$$

Since the desorption step governs the decomposition, the rate of the reaction is given by

$$k_d e^{h\theta_N} = k_d (a_0 K)^{h/f} (p_{NH_3}{}^2 / p_{H_2}{}^3)^{h/f}$$

This kinetic expression is applicable to the pressure dependence results of many workers on different metals, using various values of h/f in the range 0.2 to 3.8 and frequently around 0.5 (*11*). The theory merely predicts that h/f should lie between 0 and 1. It is the ratio of the coefficients of variation of the activation energy of desorption and the heat of adsorption, which are known to depend on the preparation of the catalyst.

Kinetics on Platinum

The pressure exponents obtained on different occasions for the decomposition of ammonia on platinum are given in the table, according to the expression:

$$\text{rate} = k p_{NH_3}{}^x / p_{H_2}{}^y$$

and the best value of h/f is calculated. The third set of results are for evaporated films, the others for filaments. In each case the ratio y/x is close to 3/2.

Pressure Exponents for Decomposition of Ammonia on Platinum

Authors	x	y	h/f
Schwab and Schmidt (*12*)	1.4	2.3	0.74
Apel'baum and Temkin (*13*)	1.4	2.2	0.73
Logan and Kemball (*14*)	1.0	1.6	0.52

To sum up, the effect of increasing the hydrogen pressure in ammonia decomposition is to alter the surface equilibria so as to diminish the concentration of the species participating in the rate-determining step. Since this decrease is not caused by the preferential adsorption of another species, hydrogen is not properly a strongly-absorbed inhibitor, although it does have a negative exponent in the rate equation.

Literature Cited

(1) Hinshelwood, C. N., and Burk, R. E., *J. Chem. Soc.*, **1925**, 1105.

(2) Lotz, C. R., and Sebba, F., *Trans. Faraday Soc.*, **53**, 1246 (1957); Logan, S. R., Moss, R. L., and Kemball, C., *Trans. Faraday Soc.*, **54**, 922 (1958); Tamaru, K., *Trans. Faraday Soc.*, **57**, 1410 (1961).

(3) Dixon, J. K., *J. Am. Chem. Soc.*, **53**, 1763 (1931).

(4) Kiperman, S., and Temkin, M., *J. Phys. Chem.* (USSR), **20**, 461 (1946).

(5) Trapnell, B. M. W., "Chemisorption," Butterworths; Scientific Publishers, London, **1955**, pp. 110–3.

(6) Winter, E., *Z. physik. Chem.*, **B13**, 401 (1931).

(7) Emmett, P. H., and Brunauer, S., *J. Am. Chem. Soc.*, **56**, 35 (1934).

(8) Temkin, M., and Pyzhev, V., *Acta Physiochim.* (U.S.S.R.), **12**, 327 (1940).

(9) Love, K. S., and Emmett, P. H., *J. Am. Chem. Soc.*, **63**, 3297 (1941).

(10) Brunauer, S., Love, K. S., and Keenan, R. G., *J. Am. Chem. Soc.*, **64**, 751 (1942).

(11) Kiperman, S., and Temkin, M., *J. Phys. Chem.* (USSR), **21**, 927 (1947).

(12) Schwab, G. M., and Schmidt, H., *Z. physik. Chem.*, **B3**, 337 (1929).

(13) Apel'baum, L. O., and Temkin, M. I., *J. Phys. Chem.* (USSR), **33**, 2697 (1959).

(14) Logan, S. R., and Kemball, C., *Trans. Faraday Soc.*, **56**, 144 (1960).

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Demonstrating the Weissenberg Effect with Gelatin

The increasing role of high polymers in every phase of modern life has made the study of these materials an essential part of technical education. Simple demonstrations of the behavior of high polymers can be particularly effective if they deal with materials familiar to the students and show strong effects of an unusual nature. Gelatin is well suited as a material for such demonstrations, being familiar as a food ingredient in all homes, and varying from a somewhat viscous solution in water to a firm elastic gel. The solid gel has found increasing use in stress analysis laboratories as an elastic transparent simulant of solid shapes, with adequate birefringence for model studies (*1*). In this paper gelatin is shown to be suitable for demonstration of viscoelastic solution behavior in a simple apparatus.

Herzog and Weissenberg (*2*) reported in 1928 that when certain polymers were subjected to shear, a force was developed at right angles to the direction of shear. Such behavior is consistent with the orientation of the large molecular weight polymer units by the flow in shear, and the tendency of such molecules to reorient to their normal arrangement would produce a normal force (*3*). This normal force is used to measure the viscoelastic properties of high polymer solutions in an apparatus such as the Weissenberg goniometer.

A practical effect of this normal force is the ballooning of plastics as they leave the extrusion die, so that accurate control of a finished product must take account of the effect. Another application has been shown by Maxwell and Scalora (*4*), who used the force to produce extrusion from a hole in a plate along which the polymer is being sheared.

Needing a simple demonstration in rheology for a lecture to a group of high school students, I successfully used a gelatin solution in an apparatus similar to that of Jobling and Roberts (*6*). This apparatus was easily assembled—consisting of a simple hand drill fastened base down to a ring stand support, with a 6 oz. drinking glass held in the chuck of the drill by a simple holder made out of bent metal. A clamp on the stand held a piece of glass tubing centered vertically in the glass. This apparatus is shown in Figure 1, with an inverted buret for measurement of height of fluid.

Liquids described as suitable for use in the literature, such as polyisobutylene, are not generally accessible in the home laboratory, however, so gelatin solutions in water were tested and found to produce an excellent demonstration at temperatures a degree or so above the melting point. The production of the Weissenberg effect with the thick portion of egg white was described by Muller (*5*), who suggested it as a readily accessible material for demonstrating this effect.

The gelatin used was (Knox) unflavored (USP), sold in boxes of small paper packets for home use as a protein

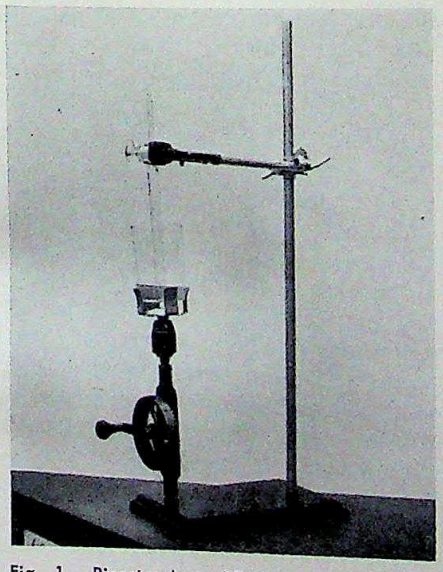

Fig. 1. Ringstand modified to take a hand drill for rotating sample. Inverted buret allows measurement of height of fluid in tube, or of pressure developed by connection to a U-tube containing water.

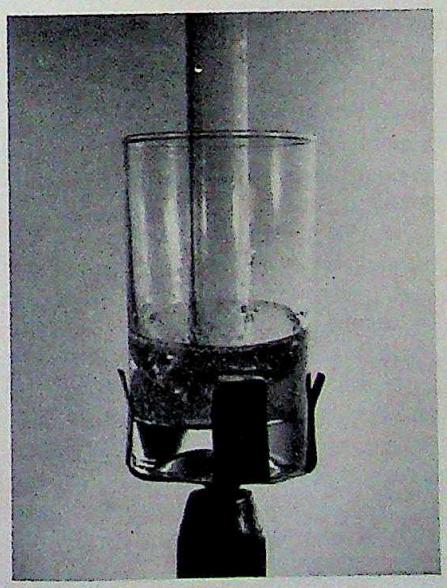

Figure 2. Typical Newtonian fluid behavior shown by gelatin solution at about 90°F when the glass is rotated at moderate speed.

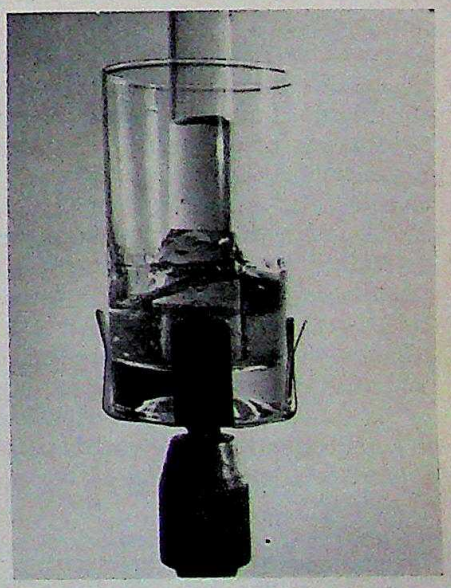

Figure 3. Weissenberg effect is clearly shown by gelatin solution at about 80°F when rotated; the solution rises inside and climbs up the outside of the stationary tube.

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food supplement or to make salads and desserts. Each packet contains 7 g which was dissolved in a glass containing 35 ml of water, hot but not over 140°F. The solution was allowed to cool to about 90°F. Rotation of the glass containing the liquid in the apparatus showed the typical Newtonian behavior of (Fig. 2), the liquid moving out against the walls of the glass as does water. When the liquid had further cooled to about 86°F, the liquid began to climb the outside of the tube and also rise inside of the tube, as shown in Figure 3. When nearly all the liquid was on or inside the tube and if the fluid had not yet reached the gel temperature the liquid would continue to climb inside the tube at the expense of the liquid on the outside of the tube. Since the gelatine solidifies at about 82°F, the tube was usually left with a solid filling, easily removed by heating the tube slightly.

Literature Cited

(1) Carmichael, A. J., and Douglas, A. G., *Australian Jour. Appl. Sci.*, 11, 272–288 (1960).
(2) Herzog, R., and Weissenberg, K., *Colloid Z.*, 46, 227 (1928).
(3) Severs, E. T., "Rheology of Polymers," Rheinhold Publishing Co., 1962, pp. 36–8.
(4) Maxwell, B., and Scalora, A. J., *Modern Plastics*, 37, No. 2, 107, Oct. (1959).
(5) Muller, H. G., *Nature*, 189, 213 (1961).
(6) Jobling, A., and Roberts, J. E., in "Rheology, Theory and Applications," Vol. 2, Eirich, F. R., ed., Academic Press, Inc., New York, 1958, plate 2, p. 522.

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Preparation and Analysis of a Complex Compound

Two trends are evident in the teaching of freshman chemistry: increased emphasis on principles in the lecture material and a greater number of quantitative exercises in the laboratory. As the theoretical content of the lectures increases, the amount of time available for descriptive chemistry decreases; and more and more dependence is placed upon student reading and laboratory work to provide the facts of chemical behavior. Experiments simply taken from quantitative analyses laboratory—valuable as they are in other ways—and introduced in the freshman laboratory to make it quantitative rarely provide the kind of interaction between principles, chemical behavior described in the text, and chemical behavior observed first hand that is so desirable. The quantitative laboratory exercise described here has been successful in integrating these three areas.

Inclusion of an exercise dealing with complex ions is almost mandatory in any modern freshman course. Certainly if the lectures reflect the "renaissance of inorganic chemistry," transition metal chemistry and crystal field theory will occupy a prominent position among the principles and descriptive chemistry covered in lectures and reading. In recent years a number of experiments have been described for undergraduate laboratory courses[1] but none has been suggested which is primarily directed toward meeting the goals of a freshman course. The synthesis of the complex described is a modification of the procedure of Hynes, Yanowski, and Shiller.[2]

The Experiment

The experiment is scheduled near the close of the second semester (it is usually followed by a 3–4 week period for an independent project) and requires three full four hour laboratory periods. The students are familiar with quantitative techniques from earlier experiments which include acid-base titration, spectrophotometry, Mohr titration of a chloride, ion-exchange resin techniques, and the turbidimetric determination of the formula and stability constant of a labile complex ion. Five lecture periods and additional readings are devoted to the chemistry of the transition metals and the structure of complexes from both the valence bond and crystal field points of view.

Each student synthesizes and purifies his own preparation during the first laboratory period, but it has been found most expedient to have students work in pairs for the analysis. There are several steps—e.g., alkaline distillation—which require long waiting periods but cannot be left completely unattended; by sharing the work of analysis it can be completed in two periods. Because his grade in part depends upon the accuracy, each student actively participates in each phase of the analyses, taking aliquots which his partner titrates, correcting his partner's technique when needed, etc. There are many natural breaks in the procedure so that rigid scheduling is not required. A discussion period held during the first week deals with the techniques of gravimetric analysis and questions from the students.

[1] Parry, R. W., this Journal, 36, 502 (1959); Holtzclaw, H. F., Jr., this Journal, 29, 95 (1952); Gayer, K. H., and Elkind, M. J., this Journal, 30, 90 (1952); Dodson, V. H., this Journal, 32, 422 (1955); and Kirschner, S., this Journal, 35, 139 (1958).

[2] Hynes, W. A., Yanowski, L. K., Shiller, M., *J. Am. Chem. Soc.*, 60, 3053 (1938).

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The compound is prepared and purified using the following procedure:[3]

Dissolve 8.0 g of $CoCl_2 \cdot 6H_2O$ in 10 ml of water. Add this solution to an evaporating dish containing a slurry of 25 g of NH_4Cl in 25 ml of concentrated aqueous ammonia and stir well. Add, *in one or two drop* portions, 5 ml of 30% H_2O_2 stirring thoroughly after each addition (CAUTION: keep H_2O_2 off of skin and eyes—it causes very painful burns!). After all the peroxide has been added, place the evaporating dish on the steam bath in the hood. Heat, with occasional stirring, for 15–30 min. The contents should be a paste or thick slurry—do not allow the contents to become dry! Rinse the paste into a 250 ml beaker containing 100 ml of 3 *M* HCl, and heat the mixture to 60° (steam bath) for 10 min. Allow to cool and filter off the precipitate using a Büchner funnel. Wash the precipitate with three 10 ml portions of ice-cold water, then with three 10 ml portions of acetone, and suck dry.

Transfer the impure precipitate to a 600 ml beaker containing 300 ml of 2 *M* aqueous ammonia and, with constant stirring, heat to 50–60°C—no higher! After a short time the precipitate will dissolve giving a deep red solution which is filtered hot (Büchner funnel) through fine filter paper. Transfer the filtrate to a one liter beaker and reheat the solution to 50–60°C. At 5 min intervals slowly add three 75 ml portions of 12 *M* HCl. The solution should be stirred continuously between and especially vigorously during addition of acid. Continue to heat and stir for an additional 15 min, then cool to room temperature. Filter and wash as before. Transfer precipitate to a weighing bottle and dry at 110° C for at least one hour.

The reactions involved in the preparation are:

$$2Co^{2+} + 8NH_3 + 2NH_4^+ + 2Cl^- + H_2O_2 \rightarrow 2[Co(NH_3)_5Cl]^{2+} + 2H_2O$$

$$[Co(NH_3)_5Cl]^{2+} + 2Cl^- \rightarrow [Co(NH_3)_5Cl]Cl_2(s)$$

The reactions involved in the purification are:

$$[Co(NH_3)_5Cl]^{2+} + H_2O \rightleftharpoons [Co(NH_3)_5H_2O]^{3+} + Cl^-$$

$$[Co(NH_3)_5H_2O] + NH_3(aq) \rightleftharpoons [Co(NH_3)_5OH]^{2+} + NH_4^+$$

Details of the analyses will not be given here since they are the standard procedures. First, some qualitative tests are made on an aqueous solution of the preparation: chloride by $Ag^+(aq)$; free ammonia by odor and *p*H paper, followed by odor upon heating strongly basic (add NaOH) solution; cobalt(II) ion by thiocyanate test in acetone solution:

$$\underset{\text{pink}}{Co(aq)^{2+}} + 4\ \underset{\text{colorless}}{SCN^-} \underset{\text{Water}}{\overset{\text{Acetone}}{\rightleftharpoons}} \underset{\text{deep blue}}{[Co(NCS)_4]^{2-}}$$

Ammonia is determined by distilling a weighed sample from strongly alkaline solution, collecting the distillate in boric acid solution, and titrating it with standard acid:

$$2[Co(NH_3)_5Cl]^{2+} + 6OH^- \rightarrow Co_2O_3(s) + 2Cl^- + 3H_2O + 10NH_3$$

Cobalt is determined using the same sample. Solid KI is dissolved in the solution remaining in the distilling flask which is then made strongly acidic with HCl. The triiodide formed:

$$Co_2O_3(s) + 3I^- + 6H^+ \rightarrow 2\ Co^{2+} + I_3^- + 3H_2O$$

is titrated with standard thiosulfate.

The total chloride in a weighed sample is determined by heating in an acidic $Ag^+(aq)$ solution and weighing the $AgCl(s)$ formed:

$$[Co(NH_3)_5Cl]Cl_2 + H_2O + 3Ag^+ \rightarrow [Co(NH_3)_5H_2O]^{3+} + 3AgCl(s)$$

A solution of the preparation is passed through a Dowex-50 cation exchange resin in the acid form. The $[Co(NH_3)_5Cl]^{2+}$ is held on the resin beads; the ionic chloride—i.e., chloride ion of the ionic lattice—in the eluent is determined by Mohr titration.

Results

The results of most student preparations are a very pure, fine-grained, purple-red crystalline product. Occasionally NH_4Cl is present; but if the product is crystalline, this is easily seen. Too rapid addition of H_2O_2 will decompose the product without oxidizing the cobalt(II) ion; this can be recognized by the blue crust which forms on the sides of the evaporating dish. The preparation sometimes can be salvaged at this point by adding aqueous ammonia and H_2O_2, but it is best to start afresh. Dissolution of the complex in the purification step is often slow especially if acid remains in the solid because of poor washing; if the precipitate does not dissolve in 10–15 min, add 15 ml of concentrated aqueous ammonia.

The analytical results obtained by careful workers differ from the calculated values by less than 0.5%, with the ammonia tending to be low. The good analytical results are probably partly fortuitous; e.g., the low results expected for the Co(III) analyses are compensated by air oxidation of iodide ion during dissolution of Co_2O_3.

Questions

In the course of the laboratory work the laboratory instructors ask the simple questions concerning technique, reactions occurring, etc., and the standard laboratory report contains a section where sources of error are discussed and estimated. In addition, there are several questions which are part of the written laboratory report. Three types of questions are asked. The first is directly concerned with the details of the experiment, e.g., technique, stoichiometry, etc. The second draws upon principles from lecture and reading to interpret or extend the experimental results. The third goes beyond the rather straight forward application of theory and demand original interpretation or speculation. These latter questions (indicated by an asterisk) are "not required" but are attempted by 10–20% of the class with perhaps half of them giving reasonably good answers.

To indicate their type and scope the questions are given in full. The list of questions is about twice as long as that for a one period experiment.

[3] Copies of the complete laboratory procedure as distributed to the students are available from the author upon request.

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1. In this experiment hydrogen peroxide is used as an oxidizing agent. How many liters of air would have to be bubbled through the reaction mixture to effect the oxidation?
2. Why would you expect the ionic chloride analyses to give high rather than low results?
3. The most likely impurity in the preparation is ammonium chloride.
   (*a*) Suppose a preparation (certainly not yours) contains 5% ammonium chloride. Compare the theoretical analysis for this mixture with that of the pure complex. Which individual analysis is most "sensitive" to the presence of this impurity?
   (*b*) Assuming a relative uncertainty of 1% in the analytical procedures and your technique (except 2% in the ionic chloride analysis), what is the minimum concentration of ammonium chloride you can determine by the most "sensitive" of the analyses?
   (*c*) Describe a procedure by which you can detect and determine the concentration of ammonium chloride impurity to two significant figures in a sample containing about 1% impurity?
4. The blue color formed in the acetone solution of potassium thiocyanate and cobaltous ion results from the presence of the labile complex ion $[Co(NCS)_4]^{2-}$.
   (*a*) Briefly describe how you would experimentally determine the formula of the complex ion in solution.
   (*b*) Using Lewis structure and/or σ and π pictures describe the binding in thiocyanate ion. Predict which is the negative end of this dipolar ion.
   (*c*) Predict whether the N or the S end of the ion points toward the metal atom in the complex.
   (*d*) How could your prediction be confirmed experimentally?

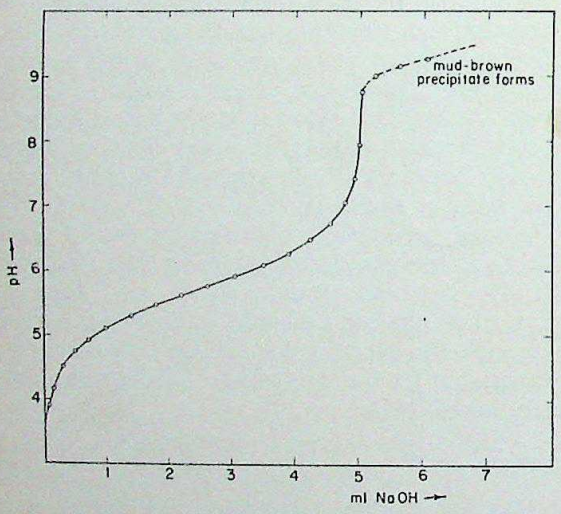

Figure 1. Titration curve of George B. Wildered.

5. George B. Wildered wanted to leave laboratory early and so modified the purification procedure. He dissolved his preparation in warm 2 *M* aqueous ammonia, filtered the solution, and then—to save time—cooled the filtered solution in an ice-bath, added the concentrated hydrochloric acid all at once, and filtered off the precipitate which formed immediately. The solid he obtained was an orange-red color instead of the purplish-red obtained by others; he also obtained a slightly higher yield of precipitate. Hy Icue, his laboratory instructor, suggested that he carefully titrate an aqueous solution of his solid with standard base using a glass electrode to measure the *p*H of the solution. The titration curve he obtained (titrating 1.3425 g of sample with 1.156 *M* NaOH) was:
   (*a*) What is the formula of the precipitate obtained under the modified conditions? Cite all the experimental evidence which supports your formulation.
   (*b*) What is the *p*K of this substance? Is this value consistent with the pK_a's of H_2O and H_3O^+ and what you know of the bonding in complexes?
   (*c*) What is the formula of the complex ion in aqueous ammoniacal solution?
6. The visible and near ultraviolet spectra of equimolar concentrations of hexamminecobalt(III) ion, $[Co(NH_3)_6]^{3+}$, aquopentamminecobalt(III) ion, $[Co(NH_3)_5H_2O]^{3+}$, and chloropentamminecobalt(III) ion, $[Co(NH_3)_5Cl]^{2+}$ are:

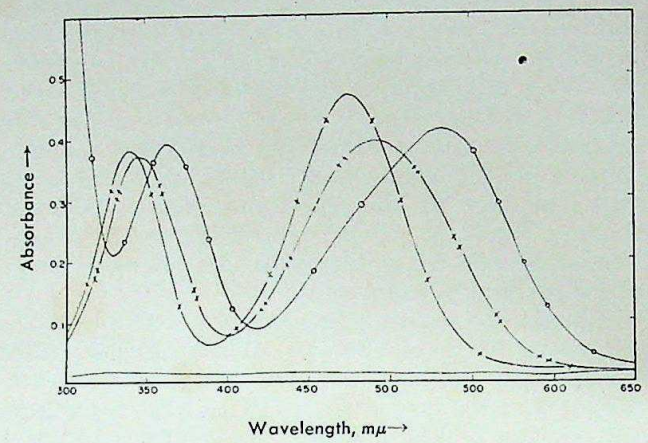

Figure 2. Visible and near ultraviolet spectra: —O—$[Co(NH_3)_5Cl]^{2+}$. —+—$[Co(NH_3)_6]^{3+}$; —++—$[Co(NH_3)_5H_2O]^{3+}$; ———cell correction;

   (*a*) Arrange the ligands in order of their crystal field strength, stating your reasoning.
   (*b*) If NH_3 has a 10 *Dq* value of 58.7 kcal/mole estimate the 10 *Dq* values of NH_3 and Cl.
   (*c*) Account for the relative magnitudes of 10 *Dq* in terms of ligand structure.

*7. Three compounds of molecular formula $[Co(NH_3)_4Cl_2]Cl$ are known. Two are exactly the same color violet, the third is a bright green.
   (*a*) Explain the existence of the three compounds accounting for the number of each color.
   (*b*) How could you distinguish between the two violet compounds?
   (*c*) How many different compounds of molecular formula $[Co(NH_3)_3Cl_3]$ can exist? Would they have different colors?

*8. It has been proposed that the intense greenish-black color obtained upon first adding the H_2O_2 solution is associated with the compound:

$$[(H_3N)_5Co—O_2—Co(NH_3)_5]^{5+}$$

What evidence can you cite to support this proposal? What experiments can be used to determine the oxidation state(s) of the cobalt?

Conclusions

Students find the experiment interesting and challenging. They are delighted when the analyses confirm the identity and purity of their compound and most will repeat discordant analyses. Many are motivated to continue work with complexes in the independent project period. Some problems which have been studied are: preparation of the nickel(II) ammine cyanide-benzene clathrate, preparation and resolution of the isomers of *cis-trans* $[Co(en)_2Cl_2]Cl$, and the rate of aquation of $[Co(NH_3)_5Cl]^{2+}$.

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Heterogeneous Equilibria in General Chemistry

A relatively recent trend in general chemistry textbooks is the development of the topics of chemical kinetics and chemical equilibria as a direct consequence of the kinetic-molecular behavior of matter instead of presenting them as additional, apparently unrelated, empirical facts. A simple diagrammatic probability analysis is employed to develop the dependence of reaction rates on concentration rather than to rely on the law of mass action (*1*). Mechanisms are introduced to show how the law of chemical equilibrium can be derived when the reaction involves more than a single bimolecular collision (*2*). These developments amplify and enforce the understanding by the student of the fundamental behavior of matter and give him an appreciation of the fact that a science is more than just a collection of observations.

A topic in this area that has steadfastly resisted modernization is the treatment of heterogeneous equilibria. The time-honored treatment of heterogeneous equilibria is to apply the law of chemical equilibrium, which was derived for homogeneous systems, to the heterogeneous cases and then take the concentrations of the substances in the pure solid and liquid phases as constant. The limitations of this procedure are threefold. First, the usual kinetic derivations of the homogeneous equilibrium constant do not allow its application to heterogeneous systems. Second, the application of the term "concentration" to a solid immobile substance is of doubtful significance. Finally, the concentration of a substance in the solid or liquid phase is not the pertinent concentration, but rather the concentration of the substance at the site of the reaction (at the solid surface or in the vapor phase). The second limitation has sometimes been overcome by introducing a non-mathematical definition of activity, but it is doubtful if this leads to any real enlightenment of the student. The third limitation has sometimes been partially overcome by pointing out the constancy of the vapor pressure of a pure liquid or pure solid at constant temperature, but this does not afford an explanation when the reaction site is the surface of the solid. To date, no method of overcoming the first, and probably the major, limitation in the treatment of heterogeneous equilibria in general chemistry has been devised. Perhaps there has been a lack of incentive because of the ease with which the law of chemical equilibrium follows from the mathematical definition of activity.

The only solution to the difficulties encountered in presenting the topic of heterogeneous equilibria (short of giving half of a course in thermodynamics) seems to be a kinetic derivation of the equilibrium constants for the various types of heterogeneous equilibria. That is, the procedure used to derive the law of chemical equilibrium for the homogeneous cases by equating reaction rates at equilibrium (*2*) can be extended to the derivation of equilibrium constants for heterogeneous equilibria. This procedure, based on chemical kinetics, is generally referred to as a kinetic derivation to distinguish it from a derivation based on thermodynamics, which is referred to as a thermodynamic derivation. The kinetic derivation is facilitated for the more complex cases of heterogeneous equilibria by employing mechanisms with activated complexes. The activated complexes of the absolute-reaction rate theory are now generally mentioned in general chemistry textbooks (*3*), but no attempt seems to have been made to integrate more fully this idea with the remainder of the discussion of reaction kinetics.

To illustrate how the activated complexes are incorporated into the kinetic derivation, consider first the simple homogeneous gas reaction,

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

This reaction can be written as the sum of two steps,

Step 1. $$H_2(g) + I_2(g) \underset{r}{\overset{f}{\rightleftharpoons}} \psi(g)$$

Step 2. $$\psi(g) \underset{r}{\overset{f}{\rightleftharpoons}} 2HI(g)$$

In these steps, $\psi(g)$ is the activated complex at the top of the energy barrier which can decompose to form either the reactants, H_2 and I_2, or the products, 2HI. When the system is in equilibrium, the reactions for both steps must be in equilibrium, and,

$$k_{1f}[H_2(g)]\,[I_2(g)] = k_{1r}[\psi(g)] \qquad (a)$$

$$k_{2f}[\psi(g)] = k_{2r}\,[HI(g)]^2 \qquad (b)$$

Then equation (*a*) is solved for $[\psi(g)]$ and this value is substituted into equation (*b*). After rearranging to group the specific reaction rate constants together, one obtains,

$$\frac{[HI(g)]^2}{[H_2(g)][I_2(g)]} = \frac{k_{1f}k_{2f}}{k_{1r}k_{2r}} = K_{eq} \qquad (c)$$

where K_{eq} is the equilibrium constant, and equation (*c*) is the law of chemical equilibrium expression for the reaction of H_2 and I_2. Homogeneous reactions which involve more steps can be treated similarly. When more than two steps are involved, it is easier to arrive at the law of chemical equilibrium from the rate equations, (*a*) and (*b*) above, by dividing them in a way that will cause the concentration of the activated complex to cancel out and also give the concentrations of the products in the numerator of the resulting expression. In the above case, equation (*b*) is reversed and divided by equation (*a*), $[\psi(g)]$ cancels out, and the constants are grouped together to give (*c*).

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After this procedure has been established for homogeneous systems, it can then be applied to the various types of heterogeneous systems. The simplest case to start with would be where the reaction site is the vapor phase as in the reaction,

$$H_2(g) + S(l) \rightleftarrows H_2S(g)$$

This reaction is written as the sum of three steps,

Step 1. $$S(l) \underset{r}{\overset{f}{\rightleftarrows}} S(g)$$

Step 2. $$H_2(g) + S(g) \underset{r}{\overset{f}{\rightleftarrows}} \psi(g)$$

Step 3. $$\psi(g) \underset{r}{\overset{f}{\rightleftarrows}} H_2S(g)$$

To write the rate equation for step 1 it is necessary to point out that the rate of escape of molecules from a liquid at constant temperature is directly proportional to the amount of surface through which the molecules can escape, that is, the surface area of the liquid. Further, the rate of condensation of the vapor molecules at constant temperature is directly proportional to the area of liquid which they can strike, that is, again the surface area of the liquid. These considerations are presented in some general chemistry textbooks (*4*) to give a verbal derivation of the constancy of vapor pressure at constant temperature, but no one seems to have expressed this mathematically as is done in equation (*a*) below. The argument for equation (*a*) is thus similar to that employed by Langmuir in the kinetic derivation of his monolayer adsorption equation (*5*). The principal difference is that in this case the surface area for both the condensation and evaporation steps is the same. The number of molecules in the liquid phase which strike the surface per unit time is a function only of the temperature, but the number of molecules in the gas phase which strike the surface per unit time will be a function of the concentration of the molecules in the gas phase. With these considerations, and, letting x be the surface area of the liquid sulfur, the following rate equations can be written for the three steps.

$$k_{1f}(x) = k_{1r}(x)[S(g)] \qquad (a)$$

$$k_{2f}[H_2(g)]\,[S(g)] = k_{2r}[\psi(g)] \qquad (b)$$

$$k_{3f}[\psi(g)] = k_{3r}[H_2S(g)] \qquad (c)$$

Equation (*c*) is reversed, divided by equation (*b*) and by equation (*a*). Common terms are canceled and the constants collected together to give,

$$\frac{[H_2S(g)]}{[H_2(g)]} = \frac{k_{1f}k_{2f}k_{3f}}{k_{1r}k_{2r}k_{3r}} = K_{eq} \qquad (d)$$

A more complicated example is offered by the reaction,

$$C(s) + CO_2(g) \rightleftarrows 2CO(g)$$

where the reaction site is the surface of the solid carbon. This reaction can be written as the sum of:

Step 1. $$C_x(s) + CO_2(g) \underset{r}{\overset{f}{\rightleftarrows}} \psi(s)$$

Step 2. $$\psi(s) \underset{r}{\overset{f}{\rightleftarrows}} \Phi(s) + CO(g)$$

Step 3. $$\Phi(s) \underset{r}{\overset{f}{\rightleftarrows}} C_{x-1}(s) + CO(g)$$

In this example $\psi(s)$ and $\Phi(s)$ are activated complexes on the surface of the solid carbon. To write rate equations for this case it is necessary to have some measure of the concentrations of $\psi(s)$ and $\Phi(s)$ on the surface of the carbon. A concentration on a solid surface would have significance if the molecules were mobile on the surface and if the surface was energetically homogeneous. Under these conditions all equal units of surface area would contain the same time average number of molecules. Many adsorbed molecules and surface molecules have been shown to be mobile (*6*), but an energetically homogeneous solid surface is probably the exception rather than the rule (*7*). Therefore, it is customary to employ as a measure of the surface concentration of a species the fraction of the total surface area which is covered by that species. This is the procedure that was employed by Langmuir in the kinetic derivation of his monolayer adsorption equation (*5*), and is the procedure employed in the discussion of heterogeneous reaction rates in physical chemistry (*8*). In the previous example only one surface area was involved, the surface area of the liquid sulfur. In this example there are three different surface areas to consider: the free carbon surface, the surface covered by $\psi(s)$, and the surface covered by $\Phi(s)$. Taking for convenience the total surface area as unity, and letting x be the area of the solid covered by $\psi(s)$ and y be the area covered by $\Phi(s)$, then $(1 - x - y)$ is the free carbon surface. The rates of the first order reactions of the activated complexes will depend only on the amounts of the activated complexes and this is given by the amounts of surface that they cover. With these considerations the following rate equations can be written.

$$k_{1f}[CO_2(g)]\,(1 - x - y) = k_{1r}(x) \qquad (a)$$

$$k_{2f}(x) = k_{2r}(y)[CO(g)] \qquad (b)$$

$$k_{3f}(y) = k_{3r}[CO(g)]\,(1 - x - y) \qquad (c)$$

Again, equation (*c*) is reversed, divided by equation (*b*) and by equation (*a*). Common terms are canceled and the constants collected together to give,

$$\frac{[CO(g)]^2}{[CO_2(g)]} = \frac{k_{1f}k_{2f}k_{3f}}{l_{1r}k_{2r}k_{3r}} = K_{eq} \qquad (d)$$

One of the most common examples of a heterogeneous equilibrium that is employed in general chemistry is the thermal decomposition of calcium carbonate (*9*). This reaction can be treated similarly, but it must be pointed out that the reaction can occur only at a common interface of some area x between the pure solid phases of $CaCO_3$ and CaO if the pure phases are to be maintained (*10*). The reaction is written as the sum of

Step 1. $$CaCO_3(s) \underset{r}{\overset{f}{\rightleftarrows}} \psi(s)$$

Step 2. $$\psi(s) \underset{r}{\overset{f}{\rightleftarrows}} CaO(s) + CO_2(g)$$

As before, the rate of reaction of a surface species is taken to be directly proportional to the area covered by that species. Letting y be the interfacial area occupied by $\psi(s)$, then $x - y$ is the free interfacial area and is a measure of the concentrations of both the $CaCO_3$ and CaO which can undergo reaction. Since only the $CaCO_3$ and CaO which are at the common interface can react,

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$$k_{1f}(x - y) = k_{1r}(y) \qquad (a)$$

$$k_{2f}(y) = k_{2r}(x - y)[CO_2(g)] \qquad (b)$$

These relations assume that the activated complex can be only one layer in depth, the same assumption that was made in the previous example. Reversing equation (*b*), dividing by (*a*), cancelling common terms, and collecting the constants gives

$$[CO_2(g)] = \frac{k_{1f}k_{2f}}{k_{1r}k_{2r}} = K_{eq} \qquad (c)$$

This treatment of the decomposition of $CaCO_3$ can serve as a basis for the introduction and the explanation of autocatalysis, where the rate of a reaction increases with the degree of completion of the reaction. Under non-equilibrium conditions the rate of decomposition of $CaCO_3$ will be directly proportional to the area of the common interface between the $CaCO_3$ and CaO as given by the left side of equation (*a*) above. Starting out with pure $CaCO_3$ the interfacial area will be negligible, but as the reaction proceeds the interfacial area must increase and the rate of the decomposition will therefore increase. Another example of this is given by the phenomenon known as tin disease in which the cubic crystals of tin are reported to be a catalyst for the conversion of the tetragonal crystals to the cubic crystals of tin (*11*). In these cases the autocatalysis is brought about because the effective concentration of the reactant as measured by the interfacial area increases as the reaction proceeds. A second type of autocatalysis is observed when a product of the reaction is a catalyst for the reaction. In the two examples given here the interfacial area cannot be called a catalyst because it is consumed when the reaction goes to completion. A catalyst can be defined as a substance that reacts and is produced in a reaction in a mole ratio of one to one.

Solubility Equilibria

Another type of heterogeneous equilibrium constant that is important to general chemistry and qualitative analysis is the solubility product constant. The solubility product constant can be derived in a similar manner if allowance is made for the uncertainty in the extent of the hydration of ions. Taking $BaSO_4$ as an example and combining the successive reactions with water molecules into a single step to simplify the derivation gives the following,

$$BaSO_4(s) \equiv Ba^{++}(s) + SO_4^{=}(s)$$

Step 1.

$$Ba(s)^{++} + \alpha H_2O \underset{r}{\overset{f}{\rightleftarrows}} \psi(s)$$

Step 2.

$$\psi(s) \underset{r}{\overset{f}{\rightleftarrows}} Ba(H_2O)^{++}{}_{\alpha}(aq)$$

Step 3.

$$SO_4^{=}(s) + \beta H_2O \underset{r}{\overset{f}{\rightleftarrows}} \Phi(s)$$

Step 4.

$$\Phi(s) \underset{r}{\overset{f}{\rightleftarrows}} SO_4(H_2O)_{\beta}^{=}(aq).$$

Again, $\psi(s)$ and $\Phi(s)$ are activated complexes. Writing the water molecules in the formulas for the aqueous ions emphasizes that the solution process is a reaction between the solid ions and water molecules which, afterall, would not occur if no interaction existed. These considerations are usually presented in general chemistry textbooks to explain the process of solution (*12*), but they are then taken for granted in further discussions of solutions such as in the consideration of solubility products. Steps 1 and 3 should not in general be interpreted to represent reactions with fixed numbers of water molecules, but rather an activation of the solid ions by the water molecules. Also, the formulas for the aqueous ions should not in general be taken to contain exactly α and β molecules of water, but should be taken to represent the interaction between the ions and the water molecules which accounts for the stabilization of the ionic solution. Lewis and Randall, Debye and Hückel, and others, have shown that in dilute solutions, where the number of water molecules for steps 1 and 3 are in large excess, the properties of electrolyte solutions can be treated without reference to any specific solute-solvent interactions (*13*). The dilute solution law does not hold for concentrated electrolyte solutions and one of the explanations given is based on the decrease in the amount of water available for the hydration of the ions (*14*).

Taking a total surface area of unity, and letting x be the area of $Ba^{++}(s)$, y the area of $SO_4^{=}(s)$, and z the area of $\psi(s)$, then $(1 - x - y - z)$ is the area of $\Phi(s)$. As before, equating the forward and reverse rates for the steps above gives,

$$k_{1f}(x)[H_2O]^{\alpha} = k_{1r}(z) \qquad (a)$$

$$k_{2f}(z) = k_{2r}[Ba(H_2O)_{\alpha}{}^{++}(aq)](y) \qquad (b)$$

$$k_{3f}(y)[H_2O]^{\beta} = k_{3r}(1 - x - y - z) \qquad (c)$$

$$k_{4f}(1 - x - y - z) = k_{4r}[SO_4(H_2O)_{\beta}^{=}(aq)](x) \qquad (d)$$

Reversing equation (*d*), dividing by equations (*c*), (*b*), and (*a*), canceling, and collecting the constants and the water concentration on the right gives,

$$[Ba(H_2O)_{\alpha}{}^{++}(aq)][SO_4(H_2O)_{\beta}^{=}(aq)] = \frac{k_{1f}k_{2f}k_{3f}k_{4f}}{k_{1r}k_{2r}k_{3r}k_{4r}}[H_2O]^{\alpha+\beta} \qquad (e)$$

At low concentrations of electrolyte where the concentration of the free water is essentially constant,

$$[Ba(H_2O)_{\alpha}{}^{++}(aq)][SO_4(H_2O)_{\beta}^{=}(aq)] = K_{sp}$$

Taking the water concentration to be constant is the usual simplification procedure employed in general chemistry. This is done in the derivation of ionization constants, hydrolysis constants, and the ion-product constant of water. Because the concentration of water in pure water is 55.5 moles per liter, the simplification is taken to be valid for electrolyte solutions up to 0.1 molar. The loss in validity is no greater than that introduced by taking the equilibrium constants to be independent of concentration, that is, using concentrations instead of activities. Leaving out the water of hydration gives the solubility product expression in its usual form,

$$[Ba^{++}(aq)][SO_4^{=}(aq)] = K_{sp}$$

In all of the foregoing examples of heterogeneous equilibria it will be noted that the surfaces of the pure solid and liquid phases make an equal contribution to both the forward and reverse reactions and, therefore, the surface terms always cancel out. These terms are the x in the first example, the x, y, and $(1 - x - y)$ in the second example, the y and $(x - y)$ in the third example, and the x, y, z, and $(1 - x - y - z)$ in the fourth example. As a consequence, there is no concentration term in the resulting laws of chemical equilibria

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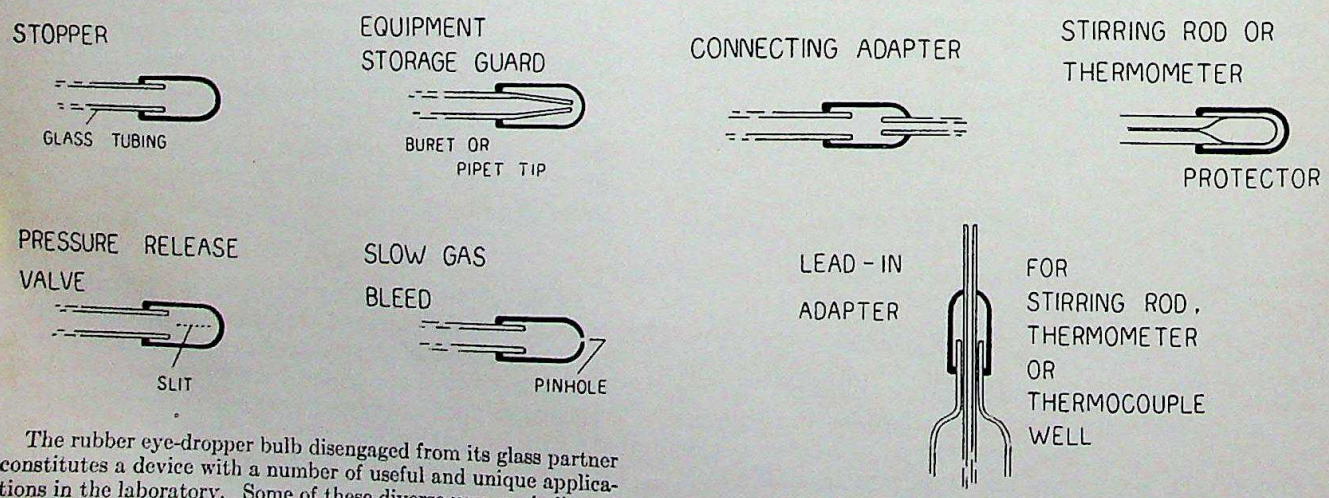
for the reactants or products that will be in the form of pure solid or liquid phases. The procedure employed for the four examples given can be used to show that this result will be true for any heterogeneous equilibrium. Also, as in the above examples, it will always be true that those concentration terms which do appear (gases and components of solutions) will be raised to a power given by the coefficient of the substance in the chemical equation. Therefore, by induction, the conclusion is reached that the law of chemical equilibrium for a heterogeneous reaction can be obtained by the application of the law of chemical equilibrium for homogeneous reactions to the equation followed by deletion of the concentration terms for all pure solid or liquid substances.

The generalization just made serves as an illustration of the inductive process of the scientific method. The kinetic derivation of equilibrium constants also affords an opportunity to demonstrate to the student in general chemistry how a theory can be checked by observations of deductions made from the theory. This point is often presented as a part of the scientific method (*15*), but there are few opportunities in general chemistry to illustrate it. The utility of deductions is limited, however, because while the non-existence of a deduction from a theory will disprove the theory, the existence of a deduction from a theory will only add to the inductive probability that the theory is correct. The existence of equilibrium constants serves as a good example, because as derived above, they are a deduction from the kinetic molecular theory of matter. The experimental verification of the existence of equilibrium constants helps to substantiate the kinetic-molecular theory, but does not prove that matter is actually composed of particles in motion. The mechanisms given for the various examples of heterogeneous equilibria also serve as an illustration of the deductive process. The existence of deductions from the mechanisms, such as autocatalysis, shows only that the mechanisms are consistent with all the observations, but does not prove that they constitute the actual processes which occur when the reactants change to the products.

Literature Cited

(1) Quagliano, J. V., "Chemistry," Prentice-Hall, Inc., Englewood Cliffs, N. J., 1958, pp. 539–42.
(2) Sienko, M. J., and Plane, R. A., "Chemistry," 2nd ed., McGraw-Hill Book Co., Inc., New York, 1961, pp. 255–6.
(3) *Ibid.*, pp. 247–9.
(4) Sisler, H. H., Vanderwerf, C. A., and Davidson, A. W., "General Chemistry, A Systematic Approach," 2nd ed., The Macmillan Co., New York, 1959, pp. 58–60.
(5) Adamson, A. W., "Physical Chemistry of Surfaces," Interscience Publishers, Inc., New York, 1960, pp. 464–72.
(6) *Ibid.*, pp. 551–5.
(7) Mysels, K. J., "Introduction to Colloid Chemistry," Interscience Publishers, Inc., New York, 1959, pp. 192–4.
(8) Prutton, C. F., and Maron, S. H., "Fundamental Principles of Physical Chemistry," The Macmillan Co., New York, 1944, pp. 654–6.
(9) Nebergall, W. H., and Schmidt, F. C., "College Chemistry," D. C. Heath and Co., Boston, 1957, pp. 232–3.
(10) Adam, N. K., "The Physics and Chemistry of Surfaces," Oxford University Press, London, 1944, pp. 241–4.
(11) Nebergall, W. H., and Schmidt, F. C., *op. cit.*, p. 537.
(12) Sisler, H. H., et al., *op. cit.*, pp. 216–9.
(13) Barrow, G. M., "Physical Chemistry," McGraw-Hill Book Co., Inc., New York, 1961, pp. 564–73.
(14) Harned, H. S., and Owen, B. B., "The Physical Chemistry of Electrolytic Solutions," 2nd ed., Reinhold Publishing Corp., New York, 1950, pp. 606–9.
(15) Nebergall, W. H., and Schmidt, F. C., *op. cit.*, p. 11.

Uses for Rubber Eye-dropper Bulbs



The rubber eye-dropper bulb disengaged from its glass partner constitutes a device with a number of useful and unique applications in the laboratory. Some of these diverse uses are indicated in the drawing. The purpose and details of each adaptation are self-explanatory.

Meyer M. Markowitz and Daniel A. Boryta
Foote Mineral Co., Exton, Pennsylvania

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The Preparation of Inexpensive Lantern Slides

The obvious value of lantern slides for the presentation of material before groups requires little comment. The traditional $3^1/_4$- × 4-in. glass mounted slides have enjoyed widespread popularity despite their bulk, fragility, and the necessity for costly professional help in preparing them. The proper use and preparation of these relatively expensive slides is described in the American Chemical Society Bulletin 8, "Suggestions on How to Organize, Present, and Illustrate a Technical Paper." The purpose of this paper is to outline and illustrate a method for the preparation of plastic and cardboard mounted 2- × 2-in. slides with the use of the least expensive cameras and supplies available. The techniques described enable even the teacher or institution with a limited budget to enjoy the advantages of inexpensive, convenient, easily-prepared lantern slides.

Photographing

Any set-up for photographic copying requires an original, a camera loaded with suitable film, adequate lighting, and some method for maintaining the film plane of the camera parallel to the plane of the original. The various components involved are discussed in the following paragraphs.

The original can be prepared from black construction paper available at most art and department stores. The material to be presented is drawn on the black surface with white ink using a steel pen point, or with a white drawing or marking pencil. Chalk can also be used, although it produces less well defined lines. A negative made from such a white-on-black original, of course, will give a conventional black-on-white projected image. Slight overexposure usually improves the projected image since one obtains more contrast between the black lettering and white background. One can also photograph chalk markings on a *clean* blackboard or slate. This technique is quite useful with inexpensive "box" cameras that focus within 3 to 6 ft. Very effective slides can also be produced from originals made with black ink or a black drawing or marking pencil on white paper. These will project to give white-on-black images similar to blackboard work. Originals must be large, and can be effectively made from newsprint and a black marking-pencil or felt-tip ink cartridge.

The relative dimensions of the original will depend on the film size employed and the focal length of the camera. For example, 35 mm film produces a negative with a 24- × 36-mm projectable area. The width-to-length ratio of the original consequently should be about 2 to 3. Many 35 mm cameras focus well at a distance as close as 1–2 ft, thus allowing the dimensions of the original to be as small as 4- × 6-in. The square 127 Superslides require a square original. The absolute size of the original will be governed by the camera and the copying arrangement; a 3 ft sq original allows convenient focusing with inexpensive cameras and the lettering can be about 3 in. high, average height for blackboard work.

A single-lens reflex camera with a lens mount that permits the use of extension tubes or a bellowscope for close-up work is ideal. With such an arrangement, 4- × 6-in. sheets of black construction paper make convenient originals. Other cameras can be equipped for close-up work with simple supplementary lenses that mount in front of the regular camera lens.[1] Tables[1] are available showing lens-to-original distance, camera setting, and field covered by various lenses. Thus, for example, a 35 mm camera equipped with a Kodak Portra 2+ Lens mounted $15^1/_2$ in. from an original with the camera focus scale set at 6 ft will cover a $7^1/_8$ × $10^1/_2$ in. area. Consequently, a standard $8^1/_2$- × 11-in. piece of black paper would make a suitable original.

Even without a supplementary lens most cameras (including "box-types") can bring objects as close as 3 to 4 ft into focus. Acceptable slides can be obtained by using large originals and heavy lettering. One can conveniently draw complicated chemical structures, for example, with chalk on black paper (approximately 3- × 3-ft), lay the paper on the ground in natural sunlight, and photograph at slightly above waist height with a simple "box-type" camera.

Regardless of the set-up employed, one test roll of film should be exposed and processed to determine the best exposure time, aperture, and lighting conditions.

The following film sizes can be used directly for the production of 2- × 2-in. slides; 35 mm, 828 (Bantam), and 12 exposure 127 (Superslides). Other sizes can be employed, but the maximum area that can be conveniently projected in conventional 2- × 2-in. projectors is about 38- × 38-mm (the Superslide projectable area). With films larger than 127, exposure must be made to allow for cropping to Superslide size ($1^5/_8$- × $1^5/_8$-in. overall). If masking is necessary, Kodak slide masking tape is most convenient.

Kodak Panatomic X, Verichrome Pan, and High Contrast Copy Film (available in 35 mm only) are

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Professor Shaw's many friends will be saddened to hear of his death in April 1963.

[1] "Copying," 6th ed., Eastman Kodak Company, New York, 1958. An "Advanced Data Book" is available at most photographic stores for $0.75.

[2] Wolbarst, J., "Modern Photography," 26, 38 (1962).

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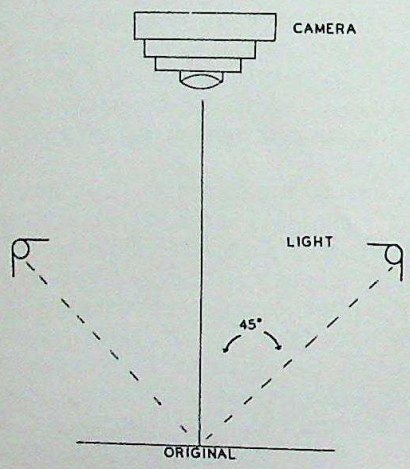
well suited for copy work,[1,2] but other films, of course, can be employed.

Either a horizontal or a vertical copying arrangement is possible. An adequate horizontal arrangement can be made by placing the camera and lights on a small sturdy table near a wall. The original is fastened to the wall with masking tape. Masking tape that is sticky on both sides such as Scotch Brand Double Stick Tape is particularly convenient. Ringstands equipped with three-fingered clamps can be used to hold the lights or two goose-necked desk lamps can be employed. Many photographers prefer photoflood lamps with built-in reflectors that can be purchased from most photography stores. Ordinary 100 W or more powerful regular tungsten lamps will also serve. This horizontal copying arrangement is best for use with inexpensive cameras and large originals. More elegant devices have been described.[1]

The vertical arrangement can be made with a heavy-duty ringstand clamped to the back edge of a sturdy table or desk with a C-clamp. A clean ring is next mounted on the stand so that the center of the ring is over the center of the table. Many 35 mm cameras will rest securely in a standard-sized ring mounted in such a fashion. The original is then placed on the surface of the table directly below the camera lens with the lights arranged on either side (Fig. 1). The particular arrangement depends greatly on the type of camera and the close-up equipment available.



Some camera types minimize the problems of focusing and viewing copy material. With the single-lens reflex camera, light reflected from the original passes through the camera lens, impinges on a mirror, and strikes a ground glass surface or a pentaprism. The image so formed corresponds accurately with the image produced on film when the shutter release is activated, the mirror lifts, and the film is exposed. Unless such through-the-lens viewing is employed, parallax problems are encountered. These can be overcome in various ways. If the back of the camera is removable, focusing and framing can be accomplished by placing a piece of ground glass or tissue paper in the film plane. When the optimum arrangement is determined, the lens-to-object distance is measured with the camera position and setting noted. The camera is then loaded with film, returned to the exact position occupied before, and the film can be exposed with surety. If camera construction does not permit the use of this procedure, a plumb bob and level can be employed with a vertical copying arrangement to place the center of the original directly below the lens. If a horizontal setup is being used, the center of the original can be placed in approximate alignment with the lens using a level and a straight object such as a meter stick.

In all copy work a cable release can be most helpful.

Processing

For the most rapid results Unibath[3] is excellent. The film is loaded into a light-tight tank in total darkness. When loading is completed the lights are turned on and a single chemical solution is poured into the tank. The tank is opened after a few minutes in the solution; the processed film is washed in running water and hung to dry. The entire operation usually requires less than one hour. Control of temperature and processing time is relatively unimportant. More conventional photographic techniques, of course, can be employed. With Kodak Panatomic X film,[2] Kodak Dektol Developer stock solution diluted 1:10 gives excellent results. Development time should be 4–6 min at 20°C,[4] followed by a water rinse, conventional fixation, washing, and drying.

If the slides are not needed immediately, commerical processing is satisfactory and inexpensive. In our locality, one-day commercial development service is available for less than 25¢ a roll.

Mounting

Cardboard Kodak Ready Mounts are available from most photo stores in 35 mm, 828 (Bantam), and 127 Superslide sizes. With these a negative is cut from the dried, processed film roll and centered in the mount; the mount is sealed with a hot flat iron. Plastic mounts can also be obtained in 35 mm and Superslide sizes.[5] These new mounts are particularly convenient since they simply snap shut without requiring heat sealing and negatives are easily removed so that the plastic mount can be reused.

Conclusions

Employing the techniques described, slides can be obtained at a cost of 5–10¢ apiece. They can be readily filed in small boxes. If plastic mounts are used, the negatives can be removed from the mounts and stored in envelopes, or the slides can be stored as mounted and ready for immediate projection. Total investment in equipment, including the camera[6] and developing tank, can be as low as $7. Special effects can be produced by coloring directly on the finished slide with a felt-tip marking pen.

[3] Unibath is manufactured by Cormac Chemical Corporation, 80 Fifth Avenue, New York 11, N. Y., and is available at most photographic stores. Good plastic developing tanks may be obtained for as little as $3. An example is the Yankee Clipper II, Yankee Photo Products, 3325 Union Pacific Ave., Los Angeles 23, California.

[4] With such treatment, Panatomic X should be rated at an ASA film speed of 50–64.

[5] Available by mail from Mr. E Enterprises, 8715 La Tijera Blvd., Los Angeles 45, California. These are sent in plastic boxes: $3.50 per 100 mounts, 35 mm or Superslide only.

[6] An Imperial Satellite, Imperial Camera Corporation, 421 North Western Ave., Chicago 12, Illinois, was used in our work.

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A Simple Condensation Isotherm for a Hard Sphere Gas

Theoretical evidence for the existence of what may be first-order phase changes in systems having no intermolecular attractive forces (hard sphere fluids) has been obtained on the basis of rather involved statistical and molecular arguments (*1*, *2*, *3*). Such transitions do not involve changes in the potential or kinetic energy of the molecules, the only changes possible being those of the entropy S, volume V, and pressure P of the system. The Helmholtz free energy change $-\int PdV$ must be exactly equal to $-T\Delta S$ in any phase transition of this type. It is worth considering whether such a transition can also be derived on the basis of a simplified model, using thermodynamic arguments and a minimum number of assumptions for the purpose.

It is found here that a first-order condensation can actually occur in a hard sphere gas under the basic assumption that the effective volume of a molecule; i.e., the quantity which corresponds to b in the van der Waals equation of state is larger in the gas phase than its occupied volume in the condensed phase. Since in van der Waals equation,

$$(P + a/V^2)(V - b) = RT$$

the effective molecular volume b is four times the actual volume of a mole of hard spheres (*4*), while in a closely packed solid, the effective volume is about 1.35 times the sphere volume, the assumption seems physically reasonable. Other assumptions are that the volume and entropy per molecule of the condensed phase are independent of pressure and that the pressure and fugacity of the molecules in the gas phase are given by van der Waals equation with a equal to zero, i.e., no attractive forces.

The system to be considered consists of a mole of this hard sphere gas in a container of volume V. The effective molecular volume per mole of gas (van der Waals constant) is b and each mole of the condensed phase reduces the volume available to the gas by c, with $c < b$. A fraction n of the molecules are in the gas and $1 - n$ in the condensed phase. The entropy of the condensed state can arbitrarily be taken as zero and the total entropy of the system is then given by the entropy of the fraction in the gas phase. This entropy can be obtained from the fugacity expression for a van der Waals gas (*5*), remembering that a is zero and the free volume of the gas is $V - nb - (1 - n)c$ rather than $V - b$. The entropy of the system is then given by equation 1

$$S = n\,R \ln\left(\frac{V - c - n(b - c)}{V_0}\right) + n\,C \qquad (1)$$

where V_0 is the volume of a perfect gas in a standard state taken here to be 1 atm and the temperature of interest, and C is the entropy in the standard state. At constant volume, the equilibrium value of n is determined by maximizing S with respect to n. Differentiating (1) and equating to zero, equation (2) is obtained

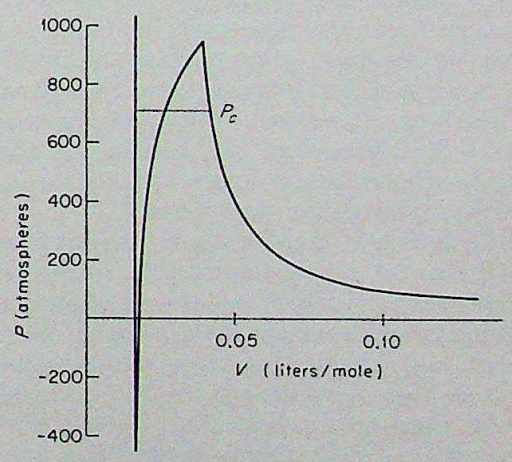
$$R \ln\left[\frac{V - c - n(b - c)}{V_0}\right] + C = \frac{n\,R(b - c)}{V - c - n(b - c)} \qquad (2)$$

The left hand side of equation 2 increases monotonically with V while the right side decreases. Since n can vary only between 0 and 1, there is only a limited range of values for which the equation can be solved. Within this range, both phases are present and the maximum entropy of the system has been obtained by a fraction of the molecules losing their entire entropy.

While equation (2) cannot be explicitly solved for n or V, pairs of values can be numerically calculated and used to obtain a PV isotherm, where the pressure-volume relationship is given by equation (3)

$$P = \frac{nRT}{V - c - n(b - c)} \qquad (3)$$

An isotherm has been calculated using as an example a set of parameters based primarily on the critical and boiling points of argon. A similar isotherm would result from any other set of parameters as long as b were greater than c. These parameters are 0.03221, 0.0161 l, 7.17 l, 17.8 eu, and 87.3° for b, c, V_0, C, and T, respectively. The condensed phase compressibility is taken as zero.



P-V isotherm for hard sphere gas.

The calculated isotherm is shown in the drawing. It is seen that aside from the discontinuous derivatives,

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the features are similar to those of van der Waals isotherms. The pressure is three valued in the condensation region and becomes negative, implying also negative non-physical values of n. The condensation pressure (P_c in the drawing) is determined as in van der Waals isotherms by the Maxwell condition (*6*); i.e., the areas between the condensation pressure line and the isotherm, above and below the condensation pressure line are equal.

The condensations derived from van der Waals equation are dependent on the attractive intermolecular forces represented by the a parameter. Hence the considerations here, also in effect, act as an attractive force leading to a condensation. Since the pressure required is about seven hundred atmospheres rather than one atmosphere for the real gas argon, it is evident that this effective force is very much weaker than the attractive force of real gases. Also if the parameters b and c could vary as a function of temperature and become equal, a critical point could be defined where no condensation was possible. However, in the hard sphere model these parameters cannot vary with temperature, and therefore no critical point is possible.

In the condensation region, the full van der Waals equation gives only a poor description of the properties of a real gas. Similarly, the hard sphere van der Waals equation gives only a rough approximation to more accurate calculations of the properties of a hard sphere gas. The value of the isotherm is then not in the quantitative results obtained, but, as with van der Waals isotherms in the insight, it gives on the general nature of a condensation. Since any hard sphere gas can only remotely resemble a real gas at low temperatures, the information obtained from rigorous hard sphere models is also largely one of insight as in the simple model used here.

Literature Cited

(1) Kirkwood, J. G., and Boggs, E. M., *J. Chem. Phys.*, **10**, 394 (1942).
(2) Alder, B. J., and Wainwright, T. E., *J. Chem. Phys.*, **31**, 459 (1960).
(3) Rice, O. K., *J. Chem. Phys.*, **31**, 987 (1959).
(4) Fowler, R. H., and Guggenheim, E. A., "Statistical Thermodynamics," Cambridge University Press, Cambridge, 1939, p. 273.
(5) Lewis, G. N., and Randall, M., "Thermodynamics," 1st ed., McGraw-Hill Book Co., New York, 1923, p. 195.
(6) *Ibid.*, p. 188.

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A Unified Kinetic Theory Description of Transport Phenomena

The phenomena of mass, momentum, and energy transfers are studied frequently in a single course; they occur simultaneously in many applications, may be described in the main by similar mathematical expressions, and are each a consequence of particle motions in a system containing macroscopic gradients. Textbooks, e.g., (*1*), treating all three of these transport phenomena under a single cover, have appeared during the past several years.

In the classroom, kinetic theory descriptions are found to be useful supplements to the more common macroscopic descriptions of these transport phenomena. The learning process is aided by the addition of another view point; also, kinetic theory appeals to mechanical visualization and provides guides for extrapolating beyond the range of existing data. The author has found that these kinetic theory descriptions are most effective if they are developed logically (and without omissions of important intermediate steps) from first principles. The realities of instruction at the upper-division or first-year graduate levels require, however, that these descriptions be brief and use only modest mathematical techniques. The methods of Chapman and Enskog (*2*) consequently are unsuitable for presentation at these levels. As a result, the diffusion (or mean free path) approximation, developed so effectively by Meyer (*3*), has been modified to provide an efficient unified kinetic theory description of transport phenomena which embodies the salient features of the phenomena and yet can be presented, without omissions of important intermediate steps, in only one or two lectures. It is presented with the hope that other instructors will find this description effective and efficient.

Analysis

It is presumed that the students have been shown the following:

For a gas in equilibrium, the number density $f(v)d\vec{v}$ of particles in the velocity range $d\vec{v}$ is given by the Maxwell-Boltzmann distribution law:

$$f(v)\, d^{\rightarrow} = n \left(\frac{m}{2\pi kT}\right)^{3/2} e^{-mv^2/2kT} d\vec{v} \qquad (1)$$

Here n is number density of particles, m is mass of particle, k is Boltzmann's constant, T is temperature, and the velocity range $d\vec{v}$ is given (in spherical polar coordinates) by

$$d\vec{v} \equiv v \sin\theta \, d\phi \, v \, d\theta \, dv \qquad (2)$$

For a gas consisting of smooth elastic spheres in thermodynamic equilibrium, the mean free path l is related to the particle diameter σ by

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$$l = \frac{1}{\sqrt{2}\, n\pi\, \sigma^2} \tag{3}$$

whereas the fraction $f(r)$ of particles surviving a free path of length r without collision is given by

$$(r) = e^{-r/l} \tag{4}$$

These relations are developed in texts dealing with the kinetic theory of gases.

In the diffusion (or mean free path) approximation, transports of mass, momentum, and energy are attributed to particle motions in a system containing macroscopic gradients; the momentum and energy transported by each particle is characterized by the state of the gas at the location of the last collision of the particle; and the velocity distribution at each location is approximated by the Maxwell-Boltzmann distribution law corresponding to the local temperature. Using spherical polar coordinates r, θ, and ϕ, consider a differential area element located at the origin and in the plane $\theta = \pi/2$ (Fig. 1). Consider all particles whose velocities lie within the velocity range $d\vec{v}$. Of these particles, consider only those particles crossing the geometrical surface $ds \equiv r \sin\theta\, d\phi\, r\, d\theta$. Of these particles, consider only that fraction dr/l undergoing its last collision within the differential volume element $d\tau \equiv r \sin\theta\, d\phi\, r\, d\theta\, dr$. (These particles are assumed to carry with them the property g corresponding to conditions within this differential volume element.) Of these particles, only the fraction $f(r)$ survive to cross the differential area element $ds/\cos\theta$ located at the origin and in the plane $\theta = \pi/2$. A time interval dr/v is required for these particles to pass through this surface. Hence, the rate at which property g is transported across this surface by particles undergoing their last collision in the differential volume element $d\tau$, leaving in a direction such as to pass through the differential area element at the origin, and possessing a free path which reaches at least to this differential area element, may be given by

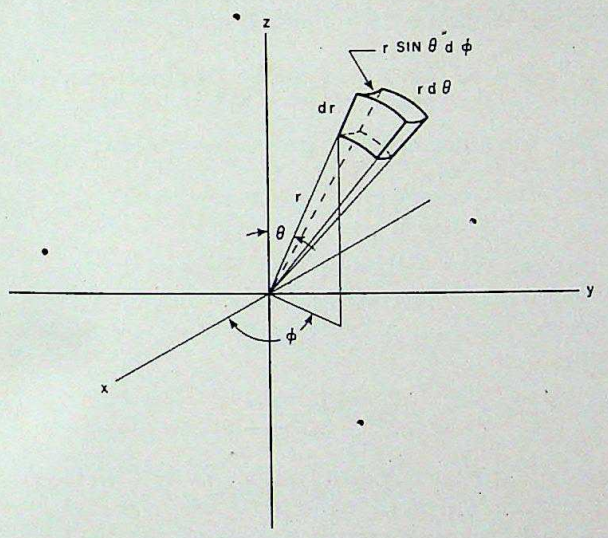

Figure 1. Coordinate system used in development of equation (5).

$$df_z = -g f(v)\, d\vec{v}\, d\tau\, \frac{dr}{l} f(r) \frac{\cos\theta}{ds} \frac{v}{dr} \tag{5}$$

where f_z is flux of property g in z-direction. Rearranging, integrating (to obtain the total flux) and using Gauss' Theorem

$$f_z = -\int_0^\infty v^3\, dv \int_0^\infty \frac{dr}{r^2} \int_0^{4\pi r^2} \frac{g f(v) f(r)}{l} \cos\theta\, ds$$

$$= -\int_0^\infty v^3\, dv \int_0^\infty \frac{dr}{r^2} \int_0^{(4/3)\pi r^3} \frac{\partial}{\partial z}\left[\frac{g f(v) f(r)}{l}\right] d\tau$$

If one retains only first-order terms in gradients, then $\partial[g\, f(v)\, f(r)/l]/\partial z$ is a constant in the volume integration. Hence

$$= -\frac{4\pi}{3} \int_0^\infty v^3 dv \int_0^\infty r \frac{\partial}{\partial z}\left[\frac{g f(v) f(r)}{l}\right] dr$$

$$= -\frac{4\pi}{3} \frac{\partial}{\partial z} \int_0^\infty v^3\, dv \int_0^\infty g\, l\, f(v) \frac{r}{l} e^{-r/l}\, d(r/l)$$

(Replacing the integrals of the differential by the differential of the integrals is justified since the limits of the integrations are not functions of the coordinate z.) Carrying out the indicated integrations, keeping in mind that the property g might be a function of the speed v, one obtains

$$f_z = -\frac{1}{3} \frac{\partial}{\partial z} \int_0^\infty v\, g\, l\, f(v)\, 4\pi v^2\, dv$$

$$\equiv -\frac{1}{3} \frac{\partial}{\partial z} (n\, \overline{vg}\, l) \tag{6}$$

Equation (6) relates, in the diffusion approximation, the flux of property g with a gradient involving the property g.

Now consider the gas to be a mixture of two species, both species having very nearly the same particle diameter and particle mass. (One might consider, e.g., a mixture of two isotopes of a chemical element.) Let g equal, in turn, the mass mc^{K}, the x-momentum mv_{ox} and the translational energy, $mv^2/2$, with c^{K} the mass fraction of species K and v_{ox} the mass-average velocity in the x-direction. Set the mass-average velocity in the z-direction equal to zero. Then one obtains, in turn, for fluxes of mass of species K, x-momentum and translational energy,

$$f_z\,(\text{K-mass}) = -\frac{1}{3} \frac{\partial}{\partial z} (\rho\, l \bar{v}\, c^{\mathrm{K}}) \tag{7}$$

$$f_z\,(x\text{-momentum}) = -\frac{1}{3} \frac{\partial}{\partial z} (\rho\, l\, \bar{v}\, v_{\mathrm{ox}}) \tag{8}$$

$$f_z\,(t\text{-energy}) = -\frac{1}{3} \frac{\partial}{\partial z} \left(\rho\, l\, \bar{v}\, 2 \frac{kT}{m}\right) \tag{9}$$

Differentiating by parts,

$$f_z\,(\text{K-mass}) = -\frac{1}{3}\left[\rho l \bar{v} \frac{\partial c^{\mathrm{K}}}{\partial z} + c^{\mathrm{K}} \frac{\partial(\rho l \bar{v})}{\partial z}\right] \tag{7a}$$

$$f_z\,(x\text{-momentum}) = -\frac{1}{3}\left[\rho l \bar{v} \frac{\partial v_{\mathrm{ox}}}{\partial z} + v_{\mathrm{ox}} \frac{\partial(\rho l \bar{v})}{\partial z}\right] \tag{8a}$$

$$f_z\,(t\text{-energy}) = -\frac{2}{3} \frac{k}{m}\left[\rho l \bar{v} \frac{\partial T}{\partial z} + T \frac{\partial(\rho l \bar{v})}{\partial z}\right] \tag{9a}$$

Summing equation (7a) over both species, one obtains for the total mass flux in the z-direction

$$f_z\,(\text{mass}) = -\frac{1}{3} \frac{\partial(\rho l \bar{v})}{\partial z} \tag{10}$$

Since the right-hand side of equation (10) does not vanish in general, it appears to contradict the fact that the mass-average velocity in the z-direction was set equal to zero. This apparent contradiction is a consequence of approximating the velocity distribution by

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the Maxwell-Boltzmann distribution corresponding to the local temperature. Hence, it is in keeping with the accuracy of the diffusion approximation to neglect the last term in equations (7*a*), (8*a*), and (9*a*) and write

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$$f_z\,(\text{K-mass}) = -\frac{1}{3}\rho l\bar{v}\frac{\partial c^{K}}{\partial z} \tag{7b}$$

$$f_z\,(x\text{-momentum}) = -\frac{1}{3}\rho l\bar{v}\frac{\partial v_{ox}}{\partial z} \tag{8b}$$

$$f_z\,(t\text{-energy}) = -\frac{1}{3}\frac{2k}{m}\rho l\bar{v}\frac{\partial T}{\partial z} \tag{9b}$$

These expressions are to be compared with Fick's law for mass diffusion, Newton's law of viscosity and Fourier's law for heat conduction

$$f_z\,(\text{K-mass}) = -\rho D\frac{\partial c^{K}}{\partial z} \tag{7c}$$

$$f_z\,(x\text{-momentum}) = -\eta\frac{\partial v_{ox}}{\partial z} \tag{8c}$$

$$f_z\,(t\text{-energy}) = -\lambda\frac{\partial T}{\partial z} \tag{9c}$$

where D is the diffusion coefficient, η is the viscosity coefficient and λ is the thermal conductivity. It follows that, to the present approximation,

$$D = \frac{1}{3}l\bar{v} = \frac{1}{3}\frac{1}{\sqrt{2}\,n\pi\sigma^2}\left(\frac{8}{\pi}\frac{kT}{m}\right)^{1/2} \tag{11}$$

$$\eta = \frac{1}{3}\rho l\bar{v} = \frac{1}{3}\frac{\rho}{\sqrt{2}\,n\pi\sigma^2}\left(\frac{8}{\pi}\frac{kT}{m}\right)^{1/2} \tag{12}$$

$$\lambda = \frac{4}{15}\rho c_p l\bar{v} = \frac{4}{15}\frac{\rho c_p}{\sqrt{2}\,n\pi\sigma^2}\left(\frac{8}{\pi}\frac{kT}{m}\right)^{1/2} \tag{13}$$

where $c_p = 5k/2m$. Since the number of internal degrees of freedom has no effect on mass and momentum transfers, equations (11) and (12) apply to polyatomic particles as well as to monatomic particles. However, since only translational energy was considered in the development presented here, equation (13) (with $c_p = 5k/2m$) is applicable only to monatomic particles. It is seen that D is proportional to the 3/2 power of temperature and is proportional inversely to pressure whereas η and λ are proportional to the $^1/_2$ power of temperature and are independent of pressure.

The following dimensionless groupings of the transport coefficients are found to be convenient:

$$\frac{c_p\eta}{\lambda} = \text{Prandtl number} = \text{Pr} = {}^5/_4 \tag{14}$$

$$\frac{\eta}{\rho D} = \text{Schmidt number} = \text{Sc} = 1 \tag{15}$$

$$\frac{\lambda}{\rho c_p D} = \text{Lewis number} = \text{Le} = {}^4/_5 \tag{16}$$

Each dimensionless ratio indicates the relative abilities of the gas to transfer two properties; e.g., the Prandtl number indicates the relative abilities of the gas to transfer momentum and energy.

Discussion

The principal defects of this description of transport phenomena are (*a*) the velocity distribution has been approximated by the Maxwell-Boltzmann distribution corresponding to the local temperature, (*b*) the dependence of the free path upon particle speed has been neglected, and (*c*) the persistence of velocities after collision has been neglected. If one handles these features properly, then, for a gas consisting of smooth elastic spheres, one obtains (after considerable effort)

$$D = \frac{3\pi}{16}\frac{1}{\sqrt{2}\,n\pi\sigma^2}\left(\frac{8}{\pi}\frac{kT}{m}\right)^{1/2} \tag{17}$$

$$\eta = \frac{5\pi}{32}\frac{\rho}{\sqrt{2}\,n\pi\sigma^2}\left(\frac{8}{\pi}\frac{kT}{m}\right)^{1/2} \tag{18}$$

$$\lambda = \frac{15\pi}{64}\frac{\rho c_p}{\sqrt{2}\,n\pi\sigma^2}\left(\frac{8}{\pi}\frac{kT}{m}\right)^{1/2} \tag{19}$$

$$\frac{c_p\eta}{\lambda} = \frac{2}{3} \tag{20}$$

$$\frac{\eta}{\rho D} = \frac{5}{6} \tag{21}$$

$$\frac{\lambda}{\rho c_p D} = \frac{5}{4} \tag{22}$$

It is seen that the approximate expressions, equations (11)–(16), differ from the exact expressions, equations (17)–(22), only in values of numerical coefficients.

In the development of the expression for thermal conductivity presented here, only translational energy was considered, so that the thermal-conductivity expressions are applicable only to monatomic particles. It has been shown (*4*, *5*) that heat conduction in a nonpolar polyatomic gas is described to good approximation by a model in which the translational energy is transferred as in the case of a monatomic gas and the vibrational and rotational energies are transferred by self diffusion. Following the method of (*5*), one finds

$$\frac{\lambda}{\lambda'} = 1 + \frac{1}{\text{Le}'}\frac{c_p - c_p'}{c_p'} \tag{23}$$

so that, for a gas consisting of smooth elastic spheres,

$$\frac{\lambda}{\lambda'} = 1 + \frac{4}{5}\frac{c_p - c_p'}{c_p'} \tag{23a}$$

where the prime indicates that the property is to be calculated taking into account only translational energy. It follows that, for a gas consisting of smooth elastic spheres,

$$\text{Pr} = \frac{2}{3}\frac{10\gamma}{13\gamma - 5} \tag{24}$$

where γ is the specific-heat ratio. Note that equation (24) reduces, for monatomic particles ($\gamma = {}^5/_3$), to Pr $= {}^2/_3$ and, for many-atomic particles ($\gamma = 1$), to Pr $= {}^5/_6$.

It is to be kept in mind that all expressions for transport coefficients presented in this paper (whether approximate or exact) are for a gas consisting of smooth elastic spheres. Treatments of more complicated particles are much more tedious, (*cf.*, e.g., (*6*)).

Literature Cited

(1) Bird, R. B., Stewart, W. E. and Lightfoot, E. N., "Transport Phenomena," New York, John Wiley and Sons, Inc., 1960.

(2) Chapman, S., and Cowling, T. G., "The Mathematical Theory of Non-Uniform Gases," Cambridge, University Press, 1952.

(3) Meyer, O. E., "Kinetic Theory of Gases," London, Longmans, Green and Co., 1899.

(4) Hirschfelder, J. O., *J. Chem. Phys.*, **26**, 282–285 (1957).

(5) Knuth, E. L., *Jet Propulsion*, **27**, 1262–1263 (1957).

(6) Hirschfelder, J. O., Curtiss, C. F., and Bird, R. B., "Molecular Theory of Gases and Liquids," New York, John Wiley and Sons, Inc., 1954.

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Proceeding of the
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Conduction and Semiconduction

Empirical observations of the electrical properties of matter antedate the time of Volta, and the semiconducting behavior of organic materials has been studied since about 1906 by Pocchettino and others (*3*, *4*, *5*) who discovered and worked with the photoconductivity of anthracene. Despite this, the theoretical ground-work of solid-state chemistry was laid only a bit over 30 years ago by Wagner and Schottky (*11*).

Semiconductors are usually crystalline solids (although liquid and amorphous-solid semiconductors are known) having, in general, an electrical resistivity which is intermediate between that of typical metals and that of typical insulators, and *which decreases, usually exponentially, with temperature.* Their low conductivity is highly sensitive to light and temperature changes (and to the presence of crystal defects and impurities). Because of these properties, the study of semiconductors has yielded new theories in solid state physics and chemistry and has provided a device to test established ones. In industry, semiconducting devices are beginning to dominate the entire field of electronics, a phenomenon that is remarkable in view of the fact that the invention of the transistor occurred within the last 15 years (*1*, *6*).

The behavior of electrons in solids is not readily visualized by one accustomed to dealing with isolated atoms and molecules. Although other theoretical representations have been fruitfully applied (*9*, *10*), the *band-model* theory for metals, devised from quantum-mechanical considerations, is the most widely referred-to explanation for (their) electrical conductivity, and this was extended to cover both insulators and semiconductors. The starting point of the band theory is a collection of nuclei arrayed in space at their final internuclear separations, a (see Fig. 1). The total number of available electrons is poured into the resultant field of force, a regularly periodic field. Consider in Figure 1 the simplified model of a one-dimensional structure, the nuclei being those of sodium, for example, with a charge of +11. Due to the large electrostatic attraction, the position of each nucleus represents a deep potential energy well for the electrons. The electrons would all be at fixed levels if these wells were infinitely deep, giving rise to $1s^2$, $2s^2$, $2p^6$, $3s^1$ configurations typical of isolated sodium atoms in the ground state, as represented in Figure 1*a*. But the wells are

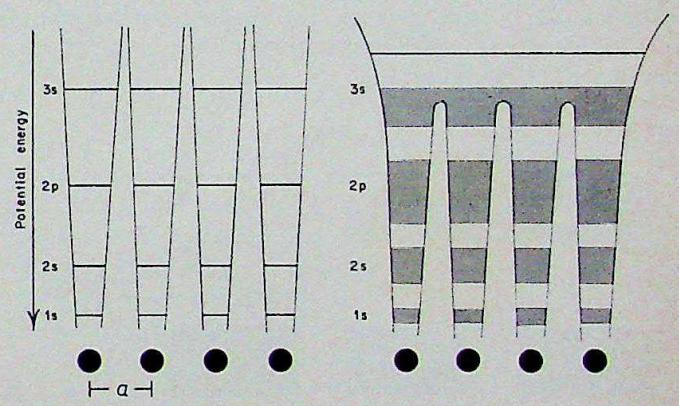

Figure 1. Energy levels in sodium: left, (a) isolated atoms; right, (b) section of solid matrix sodium.

not infinitely deep and the potential energy barriers separating the electrons on different nuclei are not infinitely high; this is shown in Figure 1*b*. Hence there can be a quantum mechanical leakage of electrons through the barriers, or, in other words, a delocalization (resonance) of electron waves to cover a large number of identical positions. Thus, we must consider not the energy levels of single sodium atoms but those of the crystal as a whole. Since the Pauli principle states that at most two electron waves (of opposite sign spin quantum number) can occupy exactly the same energy level (same n, l, m quantum numbers) and since the electron waves can now be considered as spread through the entire structure, it is clear that each energy level in an individual sodium atom is broadened in crystalline sodium into a band of closely packed energy levels (see Fig. 1*b*). Each atomic orbital contributes one

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level to a band, the levels being spaced at about 10^{-22} ev (so the band is of the order of 1 ev wide). Thus, for N atoms, each having j electronic energy levels, there result Nj levels for the crystal matrix as a whole (*7*). In the lower bands (1*s*, 2*s*, 2*p*, here) there are therefore just enough levels to accommodate the number of available electrons (i.e., the bands are completely filled), and these electrons cannot move under the influence of an external electric field. Such acceleration by the field would necessitate their moving into somewhat higher energy levels within the bands, and any levels above them are all filled. Of course, an electron may gain such a large amount of energy as to be shifted from its own band to a higher unoccupied band, but this is a rare event. In the uppermost band (3*s* here), which is only partially (half) filled, an electron toward the top of the band *may* be accelerated and move up into unfilled levels within the band. In Figure 1*b* it can be seen that the uppermost band has actually broadened enough to overtop the potential energy barriers, so that these electrons can move freely through the crystal structure (or be delocalized); when an electric field is applied, current thus flows through at this conduction band level. Ideally, if the nuclei were always arranged at all points of a periodic lattice, there should be no resistance to current flow; resistance arises from deviations from perfect periodicity. Since such deviations can be caused by thermal vibrations of lattice nuclei, sterically destroying perfect resonance between the electronic energy levels, it is easy to understand why resistance increases with temperature. Another such cause of deviations may be the introduction of foreign atoms or of imperfections in the crystal structure.

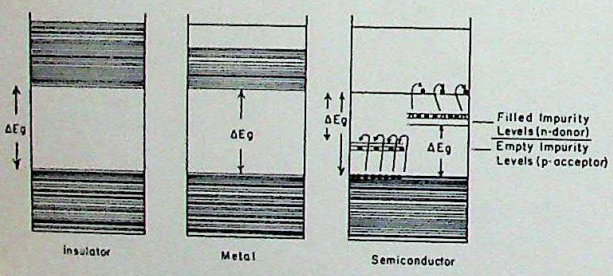

Figure 2. Band models of solids.

In the case of a metal such as magnesium, with two 3*s* electrons (zero-point ground state) and apparently completely filled 3*s* bands, conduction occurs because the 3*p* band is low enough to overlap the top of the 3*s* band, providing a large number of available empty levels. Thus, conductors are characterized either by partially-filled bands or by overlapping of the topmost bands. Insulators have completely-filled lower bands with a wide energy gap between the topmost filled band and the lowest empty band (see Fig. 2).

Energy bands in solids can be studied experimentally by the methods of X-ray emission spectroscopy. For example, if an electron is driven out of the 1*s* level in sodium metal (Figure 1*b*), the K_α X-ray emission occurs when an electron from the 3*s* band falls into the hole in the 1*s* level. Since the 3*s* electron can come from anywhere within the band of energy levels, the X-rays emitted will have a spread of energies (and hence frequencies) exactly corresponding with the spread of allowed energies in the 3*s* band. The following widths (in ev) are found for the conduction bands in a few of the metals investigated: Li, 4.1; Na, 3.4; Be, 14.8; Mg, 7.6; and Al, 13.2. Note that within a given group of the periodic table, the smaller the nuclear charge the larger the conduction-band width (as would be expected).

Band models for semiconductors are also included in Figure 2. These models usually possess, in addition to normal bands, narrow *impurity bands*—either unfilled levels closely above a filled band or filled levels closely below an empty band. The extra levels are the result of either foreign atoms dissolved in the structure or a departure from the ideal stoichiometric composition (*2*). Thus, zinc oxide normally contains an excess of zinc, whereas copper(I) oxide normally contains an excess of oxygen. Both these compounds behave as typical semiconductors. Their conductivities increase approximately exponentially with temperature, because the number of conduction electrons depends on excitation of electrons into or out of the impurity levels, and excitation is governed by an $e^{-\Delta E_g/RT}$ Boltzmann factor (*3, 4*), where ΔE_g is the energy gap between the filled and unfilled bands. This is discussed below. If this energy gap between the filled valence band and the empty conduction band is sufficiently small so that electrons are excited to the conduction band by thermal energy, a crystal may be a semiconductor even in the *absence* of effects due to impurities. Germanium, with $\Delta E_g = 0.72$ ev, and grey tin, with 0.10 ev, are examples of such *intrinsic semiconductors*. It should be noted that the removal of an electron from a filled band creates a positive "hole" (an empty energy-level) which allows conduction to occur in the valence band. Thus electrons (in the conduction band) and "holes" are the basic electrical carriers in semiconductors.

The most striking difference between metals and semiconductors is that, in the former, the number of carriers is large and constant, whereas in the latter the number is smaller and variable and may be controlled. This control may be effected by control of impurity content, but the carrier density may also be varied for a material of fixed impurity content. One of the noteworthy characteristics of semiconductors is that they show marked photo-conductive effects (*5, 8*). This is readily understood in terms of the band model. When the semiconductor is struck by light of frequency high enough so that a quantum absorbed by a valence electron has sufficient energy to raise it from the top of the full band to the conduction band, extra carriers are thereby created in the semiconductor, and these lead to increased conductivity. Photo-conduction due to excitation of electrons from impurity levels has also been observed; but since these electrons are much less numerous than the valence electrons and the levels are filled only at low temperatures, this effect is much less marked. It also appears that electrons and holes may be injected into semiconductors from metallic contacts and by other means, and also that the carriers may be extracted under suitable conditions by an electric field. This ability to control the carrier density in semiconductors is the main reason for their great technological importance.

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Generally, one type of impurity, donor or acceptor, predominates to a large extent in semiconductors used for practical purposes. When donors predominate and greatly exceed the number of intrinsic carriers, then the electron concentration, n, greatly exceeds the hole concentration, p, and the material is called "n-type"; the electrons are referred to as the majority carriers and the holes as the minority carriers. The situation is reversed for "p-type" material, in which acceptors predominate. Control of majority carriers is usually the mechanism employed in semiconductor applications, but control of minority carriers is naturally less difficult (e.g., by light injection) and has many important examples in the technology.

The electrical and optical properties of semiconductors can be explained simply on the basis of the energy band spacing of Figures 1 and 2. Figure 2 also shows the upper filled band, i.e., the valence band which contains the outer valence electrons, and the conduction band, separated by a region of width ΔE_g normally forbidden to electrons by the principles of quantum mechanics. ΔE_g is usually expressed in electron-volts. In an intrinsic semiconductor there are just sufficient electrons to fill all the bands up to the valence band and at absolute zero the conduction band would be completely empty. At a higher temperature, T, collision processes give rise to a distribution of thermal energies of the electrons around kT such that an electron in the valence band has a finite chance of being excited into the conduction band even though kT is less than ΔE_g. At temperature $T°K$, the equilibrium concentration, n, of electrons excited thermally into the conduction band is given by

$$n = QT^{3/2}(e^{-\Delta E_g/2kT})$$

where Q is a factor characteristic of the material. Other things being equal, n is thus primarily dependent on ΔE_g. For example, in germanium at room temperature $n = 2.4 \times 10^{13}$ per cc and in InSb at room temperature $n = 2 \times 10^{16}$ per cc; n is also equal to the concentration of positive holes in the valence band of intrinsic semiconductors, p.

The electrical conductivity of a pure semiconductor depends on the value of n and is given by

$$\sigma = ne(\mu_n + \mu_p)$$

where e is the electronic charge and μ_n and μ_p are the mobilities of electrons and of holes respectively, i.e., their velocities under unit applied electric field. In some semiconductors, but not all, the carrier mobilities are proportional to $T^{-3/2}$. Thus, from the expressions for n and σ given above, the conductivity varies exponentically with

$$T^{-1}[\sigma = Ze^{-\Delta E_g/2kT}]$$

and a plot of log σ versus T^{-1} should be a straight line. A typical result obtained from experimental data shows that the exponential law is followed, but only at elevated temperatures. The value of ΔE_g can be calculated from the slope of the straight line region, but this will be accurate only if mobilities follow the $T^{-3/2}$ law; otherwise the exact nature of the temperature-dependency must be known. ΔE_g itself, naturally, varies slightly with temperature. The deviation of the straight line at lower temperatures is often due to the presence of impurities or to defects in structure or composition of the crystal. These can give rise to additional energy levels in the normally forbidden region as shown in Figure 2c. The upper represents the possible situation when impurity atoms have surplus electrons which can be detached easily and excited into the conduction band. These are n-type or donor-impurities. For example, phosphorus in germanium has an average of one excess valence electron per impurity atom over the number of valence electrons of the germanium substrate, and tellurium in InSb has an average excess of two such electrons. The conductivity at low temperatures is almost entirely due to these donor electrons, and the material is said to be n-type. In the lower case of Figure 2c the impurity atoms have a deficiency of electrons and can easily capture electrons from the valence band, e.g., aluminum in germanium or zinc in InSb. Here the impurities are p-type or "acceptors" and the material is p-type. When one type of carrier predominates, the conductivity is given by $\sigma = ne\mu$. The particular temperature at which the log σ curve deviates from a straight line depends on the impurity concentration and the positions of the impurity levels in the forbidden region. The temperature region where impurity carriers predominate is called "extrinsic" and the remainder "intrinsic." At sufficiently low temperatures the number of carriers, impurity and intrinsic, n, can be negligibly small (unless the *impurity* concentration is very high), so that the semiconductor becomes an insulator. This is the reverse of metals where, at low temperatures, thermal vibrations of the periodic lattice are smoothed out and the resistance decreases to negligible values.

The *Hall effect* is a most useful effect for determining the number and type of carriers in a semiconductor, and it finds its greatest application in semiconductor measurements. It occurs when a current flows in a slice of conducting material and a magnetic field is applied at right angles to the direction of current flow. The carriers are deflected to one side or other, depending on the relative directions of magnetic field and current and on the sign of the carriers. A transverse electric field is built up across the specimen, since more charge is carried along one side than the other, until a balance occurs; and this field can be measured with a suitable voltmeter, usually a potentiometer. The field is given by $E = RJH$, where J is the current density and H the magnetic field. R is a coefficient of proportionality, the Hall coefficient, which depends on the material. In terms of measured quantities V, H, and I, where V is the Hall voltage in volts, I the total current in amps, and w and t the width and thickness of the specimen in cm, the above equation becomes

$$\frac{V}{W} = R\frac{I}{wt}H \times 10^8 \text{ or } R = \frac{Vt}{IH \times 10^8} \text{ cm}^3/\text{coulomb}$$

The direction of V shows whether the current in the specimen is carried by electrons or positive holes. The magnitude of V and thus R depends on the carrier concentration, and it can be shown that in a specimen where one type of carrier predominates, e.g., in an impurity region

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$$R = \frac{3\pi}{8ne}, \text{ thus } n(\text{or } p) = \frac{7.35 \times 10^{18}}{R}$$

(In some circumstances the factor $3\pi/8$ is replaced by 1.) Thus, R can give a measure of the concentration of "effective impurities," i.e., of those contributing carriers, and the nature of the contributing impurity can be inferred from the sign of V. When carriers of *both* types contribute to conduction, R is given by

$$R = \frac{3\pi}{8e} \frac{n\mu_n^2 - p\mu p^2}{(n\mu_n + p\mu_p)^2}.$$

Electrons can be excited into the conduction bands by absorbing energy from incident radiation, but only if the quantum energy of the radiation is greater than ΔEg. If this energy is insufficient, the electrons cannot jump the gap and the radiation cannot be absorbed by the process. A typical curve of absorption against wavelength for a semiconductor is shown in Figure 3.

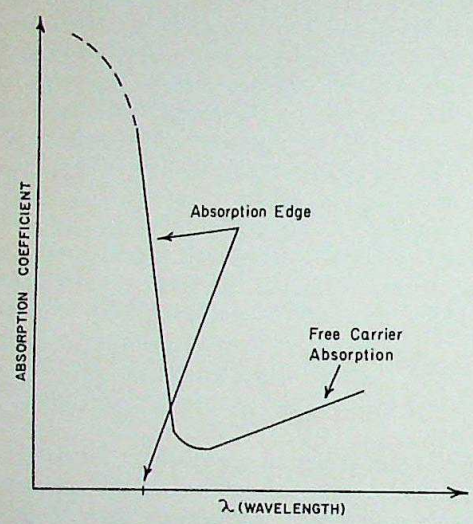

Figure 3. Spectral absorption in a semiconductor.

The wavelength at which the absorption falls sharply, the "absorption edge," occurs when the quantum energy $h\nu$ or hc/λ becomes equal to ΔE_g. Thus, at this wavelength

$$\Delta Eg = hc/\lambda = 1.24/\lambda \text{ ev}$$

This is a recognized method of determining ΔEg. Absorption beyond the edge is due to residual free carriers in the semiconductor and can give an indication of purity. Another important method for studying semiconductors is the measurement of the Seebeck effect, or thermoelectric power, as it is often called. A temperature difference across a semiconductive wafer, ΔT, gives rise to an emf of $Q\Delta T$ millivolts. This defines Q, the thermoelectric power (in millivolts/degree). The reverse of the Seebeck Effect is the Peltier effect. When a current is passed through a semiconductor, heat is absorbed at one semiconductor–metal junction and it is liberated at the other. The Peltier coefficient, π, is expressed as joules of heat absorbed or liberated reversibly per coulomb of charge passing through the junction (i.e., units of volts). Thus, $QT = \pi$, where Q is volts per degree. When a field is applied to the junction for n-type semiconductors, the electrons trying to flow into the semiconductor face an energy barrier and only the highest-energy ones can cross the barrier. Thus, the metal contact at this junction is being depleted of its most energetic electrons and at the other junction; where no such barrier exists, electrons of excessive thermal energy are added to the metal. For p-type material, holes are the carriers and must enter against a similar barrier; thus, the effect is the same but the sign of the effect is reversed. The same type of reasoning applies to the Seebeck effect. The mobile charge carriers tend to diffuse from the hot to the cold junction so that the latter acquires a potential of the same sign as the carrier, and a voltage difference results. The Seebeck effect has been used to generate power in underdeveloped areas of the world; the Peltier effect has been used to all-weather air condition homes (pump heat outside in summer, the reverse direction in the winter) in more developed nations. The measurements of the Hall effect and of thermoelectric power have been widely used in semiconductor studies. The interpretation of the Hall effect is more straightforward, and it gives more precise results when it can be measured. On low mobility materials, however, it is sometimes difficult to measure, and thermoelectric power measurements can often be made in such cases. The qualitative measurement of thermoelectric power is so simple that it is also very useful for determining the conductivity type of a semiconductor from the sign of the effect.

The *p-n* Junction

If, within the same single crystal, there are adjacent regions of n- and p-type semiconductors, the resulting boundary is called a "p-n junction." An n-type material contains mobile negative charges (conduction electrons) and an equal concentration of fixed positive charges (the ionized donors); p-type material contains mobile positive charges (holes) and fixed negative charges (ionized acceptors). With the two regions in contact, the mobile electrons and holes might be expected to flow out of the n- and p-type regions, respectively, across the junction, because of the concentration gradients for these species. On the other hand, this flow leaves the n-type region with a net positive charge and the p-type region with a net negative charge, thus establishing a field in a direction which opposes further flow. At equilibrium, this field just balances the effect of the concentration gradient. The net charges appear in the regions immediately adjacent to the p-n junction and the field appears in the *space-charge region*. Such a junction will usually act as a rectifier. In practice p-n junctions are built-in during crystal growth or are formed by diffusion of suitable impurities into a crystal or by alloying. The latter processes are called "doping."

Properties of the *p-n* Junction

In a semiconductor specimen at thermal equilibrium, the product of the conduction-electron concentration and the hole concentration in the vicinity of any point equals a constant. For germanium the value of this constant is about $5.8 \times 10^{26}/\text{cm}^6$, and for silicon, $2.3 \times 10^{20}/\text{cm}^6$. The constancy of this "pn product" is a very useful principle to invoke when describing junctions at equilibrium because it applies in all

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regions—within and near junctions as well as in uniformly-doped regions. We sometimes use

$$pn = n_i^2$$

where n_i represents the equal hole and electron concentrations found in a region which is intrinsic (i.e., which has zero net doping).

In Figure 4*a*, x is an axis passing normally through an abrupt (or step) junction. A p-region is on the left of $x = 0$, and an n region is on the right. Even though the net doping changes abruptly at $x = 0$, the carrier concentrations make their transition through a region of appreciable thickness. This is because a carrier concentration gradient is inevitably accompanied by a diffusion current, and therefore the gradient must relax to a low enough value so that an equilibrium will exist between diffusion and the counter-mechanism—drift—as described earlier. The logarithms of the carrier concentrations p and n, are plotted versus x in Figure 4*a*.

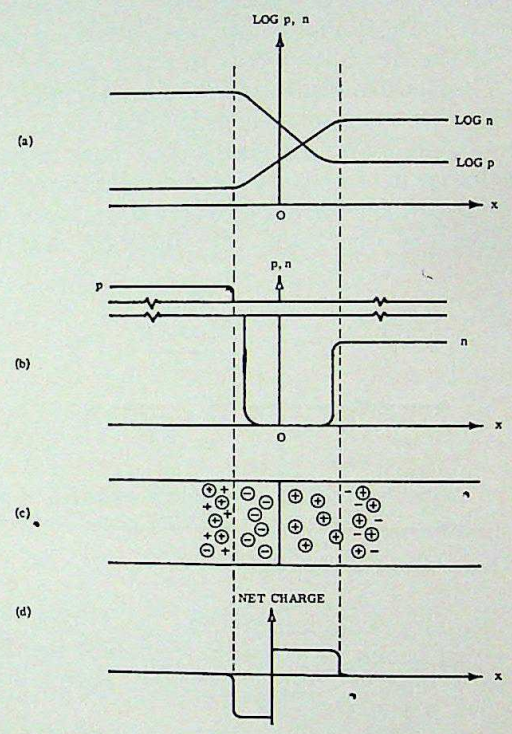

Figure 4. (a) Logarithmic plot of carrier concentrations through junction; (b) linear plot of carrier concentrations through junction; (c) ionic (circled symbols) space charge in junction; and (d) space charge distribution in step junction.

Their sum must be the same everywhere, by the pn product rule. Note that as a consequence, the height of the step in the logarithm of electron concentration is precisely equal to that for holes. Hence, carrier ratios must be equal across the junction. That is,

$$\frac{p_p}{p_n} = \frac{n_n}{n_p},$$

where the subscript indicates the region intended. Although useful, this plot conveys a distorted impression of carrier distributions within the region of changing concentration. Figure 4*b* shows carrier concentrations on a linear scale versus x. A break is indicated in the vertical direction because the majority carrier concentrations in this example are taken to differ by several orders of magnitude. Note that the majority carrier concentrations of *both* types drop sharply as one approaches the junction; hence, there is a region encircling the junction which is *practically devoid of carriers*. It is sometimes termed a "depletion layer" because of this scarcity of carriers. Further, it can be accurately treated as a region with sharp boundaries, as represented by Figure 4*c*. Here, circled charges represent impurity ions locked in the lattice and uncircled charges represent mobile carriers. The absence of carriers in the depletion layer "exposes" the ions, which then constitute a space charge, as shown in Figure 4*d*, with the same quantity of charge on each side. Accompanying the space charge is a field directed from right to left and it is this field which gives rise to the carrier drift mentioned above. Holes diffuse to the right and drift to the left in precisely compensating fashion, while electrons do just the opposite. Thus at equilibrium there are four distinct components of current crossing the junction but zero net current. The "built-in field" of a junction is responsible for the built in potential difference, which is simply related to carrier ratios across the junction as follows:

$$\frac{p_p}{p_n} = \frac{n_n}{n_p} = e^{q\delta\psi/kT}$$

where $\delta\psi$ is the height of the potential barrier in energy units and the other symbols have their customary meanings. Hence, when a voltage is applied to a junction, the pn product within the depletion layer is altered to

$$pn = n_i^2 e^{q\delta\phi/kT}$$

where $\delta\phi$ is the applied voltage. For modest forward biases ($\delta\phi$ positive) the increase in the product at the depletion layer boundaries is borne solely by an increase in minority carrier concentration, neglecting large biases. Thus

$$pn_n = n_i^2 e^{q\delta\phi/kT}$$

at the right-hand boundary, and

$$p = p_n e^{q\delta\phi/kT} \text{ so } (p - p_n) = p\left[1 - e^{q\delta\phi/kT}\right] = \Delta p e^{-x/L_p}$$

where the diffusion length, Lp, is the characteristic constant of minority carrier decay in the n region. At the x-origin boundary, the current density, J, is given by the concentration gradient times the diffusion constant (for holes in this case) times the charge on each particle

$$J = qD_p\left(\frac{\Delta p}{Lp}\right)$$

where $(\Delta p/Lp)$ can be found from the slope of the previous curve at $x = 0$. Now

$$\Delta p = p_n\left[e^{q\delta\phi/kT} - 1\right] \text{ so } J = q\frac{D_p}{Lp}p_n\left[e^{q\delta\phi/kT} - 1\right]$$

This last equation is known as the rectifier equation. A comparable equation can be written for the electron diffusion current into the p region, but in the example chosen this current is negligible because n_p is several orders of magnitude less than p_n. Thus, we have here a heavily doped p-region which is an effective emitter of holes into the more lightly doped n-region. The

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condition just described is that of forward bias or easy conduction in a rectifier. An efficient emitter junction is necessary to a practical rectifier. When the injected hole density becomes comparable to the majority electron density, then additional electrons are pulled into the region adjacent to the junction to maintain charge neutrality. This increase in both carrier population, conductivity modulation, diminishes the voltage drop in the forward-biased rectifier below the level which would otherwise be expected—clearly a desirable effect.

For reverse bias ($\delta\phi$ negative) the exponential term in the parentheses of the rectifier equation given above quickly becomes negligible compared to unity (e.g., at $\delta\phi = 0.1$ volt, it equals 0.02). Thus, under these conditions the rectifier equation predicts that the current should approach a low saturation value,

$$J_s = q \frac{D_p}{Lp} p_n$$

The model here is one of depressed pn product at the boundary (and through the depletion layer) and hence a depressed minority carrier concentration at the boundary. Therefore minority carriers (holes in this example) diffuse to the boundary to be swept through by the field. Reverse voltages beyond about 0.1 volt serve to heighten the field and thicken the depletion layer but have a negligible effect on the boundary condition; at 0.1 volt p is already a mere 2% of p_n, and hence the profile which gives rise to diffusion changes but little when reverse voltage is increased further. Electron current on the other side of the junction is again neglected for the same reasons as before.

Transistors

A simple transistor consists of three elements of semiconducting material: an emitter, a base and a collector, as shown schematically for the pnp-type in Figure 5 in the common-base connection, with biases of the correct polarity applied. Since the emitter is forward-biased, minority carriers (holes once again) flood into the base. But the reverse-biased collector

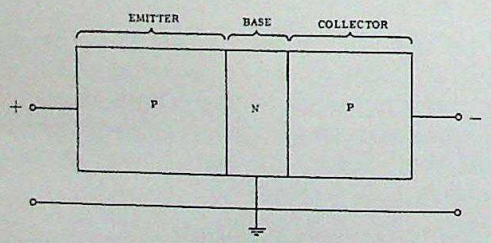

Figure 5. Basic transistor structure.

junction acts as a perfect sink for these holes, like the reverse-biased rectifier junctions just discussed. Further, since the diffusion length for holes in the base is usually substantially larger than the base thickness, the hole distribution is nearly a straight line going from a high value near the emitter to nearly zero at the collector depletion layer edge. By diffusing "down" this gradient the holes move *through* the base region. If the emitter were 100% efficient, all of the current crossing it would take the form of hole current. In practice, efficiencies between 99 and 100% are common. Also some of the holes in transit recombine and, too, the signal is often "smeared out" in transit by diffusion. An important consequence of effects such as these—emitter inefficiency, recombination in the base region and signal attenuation—is that current through the collector junction and out the collector lead is less than current entering the emitter. If we apply a low-frequency, small-amplitude signal at the emitter, these factors will lead to a smaller value of signal current at the collector than at the emitter and the current gain,

$$\alpha = \left.\frac{i_c}{i_e}\right]_{v_c}$$

where i is an ac signal and the bracket indicates that collector voltage is held constant (at ac ground) for purposes of this definition. What causes ac transverse majority carrier current? Anything which causes the current gain to be less than unity, as discussed above, will do it.

Figure 6 shows an equivalent circuit useful for describing a transistor's ac properties. The ac resistance of the emitter, r_e, follows from the rectifier equation, above. If the dc emitter bias is 1 ma, then $r_e = 26$ ohms. Thus, with freedom to increase emitter bias without limit, we can make r_e as small as we like. The equivalent circuit also includes ohmic base resistance, r_b', capacitance of the reverse-biased collector junction, C_c, and a current generator ai_e, where a is a factor differing from α. In operation, the transistor develops a

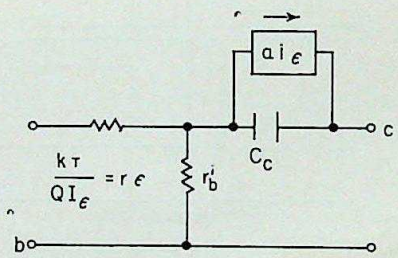

Figure 6. Transistor equivalent circuit.

voltage across a load impedance. A portion of this voltage is fed back to the input by the voltage divider formed by r_b' and C_c. The fraction of output voltage which will be fed back is

$$\frac{r_b'}{r_b' + (1/jwC_c)}$$

To minimize this feedback r_b' and C_c must be made small. Such feedback spoils the isolation between input and output. The importance of r_b' and C_c in determining amplifier gain and output can be expressed as follows. Recall that the transistor, operated as described so far, has a current gain less than unity. All of its gain is impedance gain—a current flowing in a low impedance circuit controls a current in a high impedance circuit. But r_b' represents an irreducible minimum on input impedance, and C_c imposes a limit on output impedance, at least at higher frequencies. Thus, these two parameters are directly related to the ratio of output to input impedance, or impedance gain. The signal currents at the three terminals are shown in Figure 7. Note that the current gain with the common-emitter connection (Fig. 7*b*) is

$$\beta = (\alpha/1 - \alpha)$$

The impedance gain is less in Figure 7*b* than in Figure 7*a*—though the power gain is about the same in

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either; and this is better for [illegible] such as working into a low-impedance load. In the common-emitter connection, once again r_b' represents the minimum obtainable input impedance. Using three of the above parameters we can construct a "figure of merit" which gives approximately the highest frequency of oscillation:

$$f_{max} = \sqrt{\frac{f\alpha}{25\, r_b'\, C_c}},$$

where f_α is the alpha cut-off frequency, for which α has declined 3 *db* below the low-frequency value, α_0 [i.e., f_α = frequency for which (α/α_0) is 0.707]. Let us plot

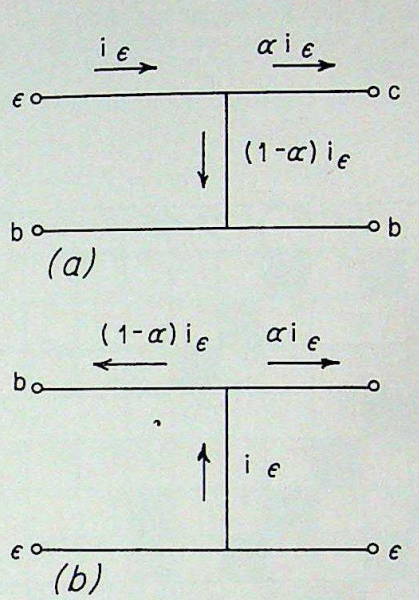

Figure 7. Transistor signal currents for (a) common base connection and (b) common emitter connection.

this number on the frequency axis of a diagram of frequency versus power, and plot a point on the other axis corresponding to the maximum allowable power dissipation for the same transistor. It is then possible to draw a smooth curve of some sort between these points as shown in Figure 8, which can be interpreted as follows: p represents the useful ac output power which can be taken from the transistor at the moderate frequency, f, for oscillator operation. The expression for f_{max} given above can be reinterpreted as a gain-band figure of merit in case one wants to know what the unit will do as an amplifier rather than as an oscillator. The expression is

$$\Gamma_0^{1/2} B = f_{max}$$

where Γ_0 is the low-frequency power gain in the common emitter connection and B is the frequency at which the power gain is down 3 *db*.

In addition to the junction rectifier and transistor, other solid state electronic devices employing these principles are in common use. Some examples include the junction capacitor, the current limiter, the integrated circuit variable resistance, the gyrator, the inductor and the zener diode.

Present electronic semiconductor devices, such as transistors, diodes, and switches nearly always utilize single-crystal wafers of ultra-pure germanium or silicon. These have the following disadvantages—low power, temperature limitations, upper frequency limitations, instability, noise, and poor resistance to radiation damage. Certain compounds of two or more elements, like GaAs, InP, and SiC have been developed for use as semiconductors with improved properties in one or more of the above areas. The most important of these new compounds for semiconductor purposes are those of the III-V and IV-IV groups. This suggests that certain organic compounds might do as well. Needed are those with a large band gap—preferably 1 ev–2 ev (for high-temperature use)—and high carrier (electron and hole) mobilities (for high frequency response), preferably 1000 cm²/volt sec, but at least 100 cm²/volt sec.

The quantum theory of semiconductors and conductors has some serious major flaws, although it has been used with great success in solid-state physics and chemistry. The results it gives, while qualitatively true, are often not quantitatively correct. The band theory is based on the periodic nature of lattices, which causes the wave functions to be periodic and hence determines the laws of motion of electrons and holes. The same band structures are found in amorphous and liquid semiconductors, which lack long-range order; the main properties of these substances are determined by nearest-neighbor interactions. The spacings and arrays formed by the atoms are more responsible for the properties than is the periodic character of the lattice. The free-motion of an electron in a periodic field of any spacing, no matter what the height of the barriers between the atoms, is in practice limited by the necessity for the wave functions to overlap and by the time required for the transitions. Band theory makes various approximations, such as neglecting direct interactions of an injected electron or hole with others. Thus,

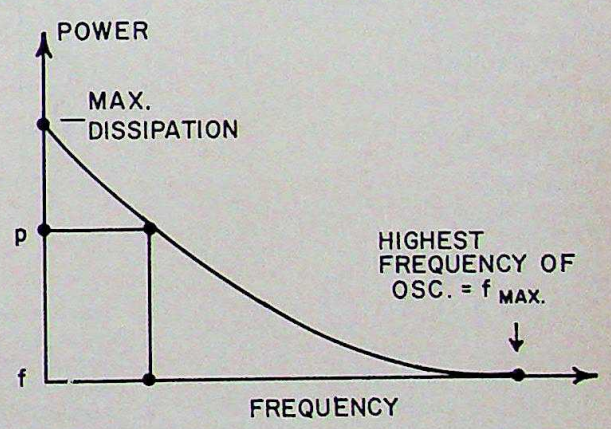

Figure 8. Oscillator power versus frequency for a particular transistor.

the predicted variation of the mobility, μ, with T is found to agree roughly with theory only for bodies with purely homopolar bonds. Theoretical predictions of how thermoelectric power varies with T agree with experiment in only a few cases for limited temperature ranges; no acceptable reason has yet been suggested for this.

We must thus recognize that our theoretical and practical studies of semiconductors, although numerous, are not yet adequate. There are many unexplained contradictions and frequently no certain correlations

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between theory and experiment. The modern quantum theory is nevertheless useful, even if inadequate to give a full and correct understanding of the enormous variety of effects found in semiconductors and of technological use. Although there are many problems which have not been cleared up, the theory can explain most of the more important effects qualitatively, if not quantitatively. It is due to the qualitative encouragement derived from the theory that the field of organic semiconductors was entered seriously by investigators from various physics and chemistry disciplines. This field is an area of investigation of the author's and a general review of it will be the subject of a subsequent paper.[2]

[2] THIS JOURNAL, in press.

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Literature Cited

(1) FORCHHEIMER, O. L., AND NEWKIRK, T. F., J. CHEM. EDUC., **38**, 183 (1961).
(2) GATOS, H. C., ed., "The Surface Chemistry of Metals and Semiconductors," John Wiley and Sons, Inc., New York, 1960.
(3) HANNAY, N. B., ed., Semiconductors," Reinhold Publishing Corp., New York, 1959.
(4) JOFFE, A. F., "Physics of Semiconductors," Academic Press, Inc., New York, 1960.
(5) POCCHETTINO, A., *Acad. Lin. Rendiconti*, **15** (1), 355 (1906).
(6) SCOTT, A. B., J. CHEM. EDUC., **38**, 224–250 (1961).
(7) SLATER, J. C., "Quantum Theory of Matter," McGraw-Hill Book Co., Inc., New York, 1951.
(8) SMITH, R. A., "Semiconductors," Cambridge University Press, Cambridge, 1959.
(9) SOMMERFELD, A., *Z. Phys.*, **47**, 1 (1928).
(10) VOLMER, M., *Ann. Physik.*, **40**, 775 (1913).
(11) WAGNER, C., AND SCHOTTKY, W., *Z. Physik. Chemie*, B **11**, 163 (1930).

Chemical Crossword Puzzle

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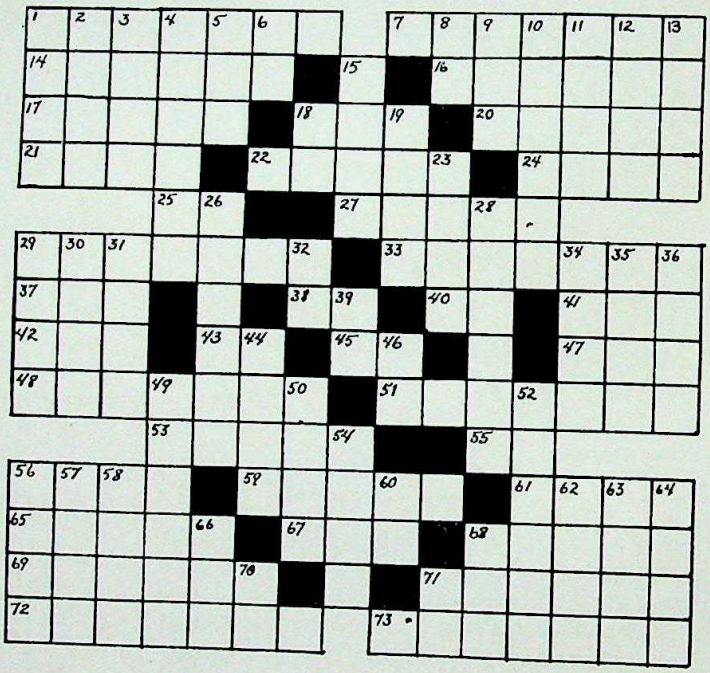

Across

1. Isotope
7. _____ energy, heat
14. Enzyme producing NH_3 and CO_2
16. Sodium _____, a soap
17. Slow (music)
18. Colloidal suspension
20. Bundle of sticks
21. Tardy
22. Concentration term
24. Fades
25. Species (ab.)
27. Behave theatrically
29. Nucleon
33. To repeat
37. All (combined form)
38. Most metallic Gr. V-A
40. Tin
41. Bad (prefix)
42. Baseball term, alkali halide
43. Metal in alloy steels
45. First transition metal
47. Motor vehicle
48. Pressure is due to molecular _____ (pl.)
51. Halogen, oxidation state +3
53. Beginning
55. Commonest alkali
56. Extend fully
59. Research collaborators
61. Woody plant
65. Type of wood
67. Diphosphopyridine nucleotide
68. Smallest units of an element
69. An aralkyl radical
71. Vinegar acid
72. Pittsburgh pro
73. Determine volumetrically

Down

1. _____ point instrument
2. Wöhler's synthetic
3. Metric prefix
4. Keep up with _____ dev.
5. Common organic prefix
6. From, of (Fr.)
8. Element 67
9. Sprite
10. Apprehender of written material
11. Wise Men
12. Minute particle
13. Permits
15. Chemical unit of reaction
18. Thus
19. Thin sheets (combined form)
23. Decomposes
26. Nucleon
28. Sinew
29. Standard
30. Occlusion (combined form)
31. Quantity specified by definition
32. Element 41
34. Both (combined form)
35. Tight
36. Other than
39. Exists
44. _____ of Tech. (ab.)
46. Old symbol, element 41
49. Electrolytes _____ in solution
50. Add a crystal
52. Subject of a chemical study
54. Narrow strip
56. Unilateral descent groups
57. Creator of artistic expression
58. Queen _____
60. Common metal with oxidation state +7
62. _____ meter, measures fluid flow
63. Give off
64. Verb suffix become
66. Solid geometric form (ab.)
68. Exert energy
70. Football position (ab.)
71. Three-toed sloth

(*See next issue for solution*)

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Chem Ed

BOOK REVIEWS

Reviewed in This Issue

J. H. Wood, C. W. Keenan, W. E. Bull, and *N. S. Bowman,* Fundamentals of College Chemistry

Katherine Blood Hoffman, Chemistry for the Applied Sciences

Howard Nechamkin, Problems in Inorganic Chemistry

Henry Eyring and *Edward M. Eyring,* Modern Chemical Kinetics

Ralph T. Overman, Basic Concepts of Nuclear Chemistry

Sidney W. Benson, Chemical Calculations

William H. Nebergall and *Frederic C. Schmidt,* General Chemistry

J. L. Hughes, Programed Instruction for Schools and Industry

Jerome P. Lysaught and *Clarence M. Williams,* A Guide to Programmed Instruction

Charles R. Dawson, editor, Chemistry 1: Atomic Structure and Bonding: A Basis Systems Program

Verne H. Booth, Physical Science: A Study of Matter and Energy

Kazuo Nakamoto, Infrared Spectra of Inorganic and Coordination Compounds

Eugene W. Berg, Physical and Chemical Methods of Separation

Alfred Prock and *Gladys McConkey,* Topics in Chemical Physics: Based on the Harvard Lectures of Peter Debye

Walter J. Moore, Physical Chemistry

Jiri Bares, et al., Collection of Problems in Physical Chemistry

Olof Samuelson, Ion Exchange Separations in Analytical Chemistry

H. H. Jaffé and *Milton Orchin,* Theory and Applications of Ultraviolet Spectroscopy

Fred W. Billmeyer, Jr., Textbook of Polymer Science

Paul D. Boyer, Henry Lardy, and *Karl Myrback,* editors, The Enzymes. Volume 6, Group Transfer; Syntheses Coupled to ATP Cleavage

William L. Nastuk, Physical Techniques in Biological Research. Volume IV, Special Methods

Marcel Florkin and *Elmer H. Stotz,* editors, Comprehensive Biochemistry. Volumes 1, 3, 4

Alex A. Kramer, Russian-English Chemical Reader: Russko-Angliiskaya Kniga dlya Chteniya po Khimii

Alexander King and *Hans Fromherz,* German-English Chemical Terminology: Englische und deutsche chemische Fachausdrücke

Anthony Standen, editor, Encyclopedia of Chemical Technology. Volume 1, A to Aluminum

Felix Sebba, Ion Flotation

Charles D. Holland, Multicomponent Distillation

I. M. Kolthoff, Philip J. Elving and *Ernest B. Sandell,* editors, Treatise on Analytical Chemistry. Part II, Analytical Chemistry of the Elements. Volumes 2 and 9

Marcel Florkin and *Elmer H. Stotz,* editors, Comprehensive Biochemistry. Volume 9

Marcel Florkin and *Elmer H. Stotz,* editors, Comprehensive Biochemistry. Volume 10

Marcel Florkin and *Elmer H. Stotz,* editors, Comprehensive Biochemistry. Volume 11

Fundamentals of College Chemistry

J. H. Wood, C. W. Keenan, W. E. Bull, N. S. Bowman, University of Tennessee, Knoxville. Harper and Row, Publishers, New York, 1963. viii + 531 pp. Figs. and tables. 17 × 25 cm. $6.75.

This text is to a large extent an adaptation and condensation of a more comprehensive text published in 1961 by two of the above authors (Keenan and Wood). The present text is designed for students preparing for careers other than professional chemists. One receives the impression that the authors made the mistake of confusing abbreviation of a rigorous text with simplification of material. This weakness is more apparent in the portions of the text dealing with the theoretical aspects of general chemistry than in the chapters devoted to descriptive inorganic chemistry.

In explaining the reasons for their approach the authors state in the preface that "To achieve the objectives of a moderate-length and interesting book, we have omitted or treated briefly certain topics which a decade ago occupied prominent positions in most general chemistry texts. On the other hand, we have presented more than is usual on such subjects as nuclear chemistry, colloids, organic chemistry and biochemistry."

No objection is made to the inclusion of relevant material on colloids and nuclear chemistry. However, this reviewer wonders, after more than thirty years of teaching both general and organic chemistry, the wisdom of including difficult material from the fields of organic and biochemistry, for example, the Haworth hexagonal cyclic (pyranose) formula for sucrose, at the expense of a more comprehensive treatment of some of the other fundamentals of general chemistry.

To be specific. Although atomic structure is discussed in Chapter 2 in keeping with modern trends, material concerning cathode rays, the discovery and characteristics of fundamental sub-atomic particles, and the like has not been included here as was done in the larger text. The student is simply told that "Modern researches indicate the existence of about twenty particles of matter. Only three of these are important in our present study: the proton, the neutron, and the electron." Although such a presentation might suffice for students having had a solid course in high-school chemistry, one questions whether students having only "average preparation and ability" will be able to formulate any worthwhile concept of the structure of atoms on the basis of such an abbreviated assertion.

The sections dealing with valence bonds also suffer from brevity of presentation. The non-polar and polar characteristics of substances receives only slight and incidental treatment. No reference is made in the index to either the Brønsted or Lewis concept of acids and bases although the Brønsted definitions are used without identifying them as such. Students taking pre-professional courses need a knowledge of these concepts as well as does the regular chemistry major. It should be pointed out that some of these concepts are treated in the "General College

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Chemistry" which was used as a text at our college for a year. We are inclined to believe in the main that this condensation of a larger and worthwhile text will not adequately meet the needs of the type of student it seeks to serve.

The format of the book is in good taste and the publishers have done their job well. An instructor's manual listing sample examinations, solutions to problems, lecture demonstrations, and the like accompanies the text.

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Chemistry for the Applied Sciences

Katherine Blood Hoffman, Florida State University, Tallahassee. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1963. xiii + 429 pp. Figs. and tables. 16 × 23.5 cm. $6.95.

This textbook is described in its Preface as "designed primarily for a one year college-level course." The title implies that it might be a suitable text for engineering students, among others. Actually it is of more limited scope. Although the author makes no statement about the type of student or the particular course toward which the book is aimed, it seems clearly to have been written to furnish a background in chemistry to home economics students or student nurses. Viewed in this light, the book has much to recommend it.

The development of the principles of chemistry, (atoms, molecules, chemical bonding, formulas, equations, types of compounds, states of matter, etc.), occupies the first 13 chapters (155 pages). Eleven chapters, (and 146 pages), develop organic chemistry from structural theory through hydrocarbons, alcohols, aldehydes, and ketones, etc., to amino acids and proteins. The author interposes a very brief Chapter 22, Unit of Life: The Cell, between cyclic compounds and carbohydrates to no particular effect. The last five chapters have primarily to do with biochemistry and physiology.

Obviously, a textbook which attempts to cover such a wide area of chemistry cannot be complete and detailed in all areas. The decision about what to include, what to abbreviate, and what to omit must be considered carefully with one's aim clearly in mind. The author assumes that the student using the textbook will have had no previous experience in chemistry. Indeed, the mnemonic devices used for the solving of simple solution concentration problems in Patterns for Writing Equations and in connection with the names of the classes of organic compounds suggest that this book is written particularly for students who, rightly or wrongly, feel that they have little talent for the physical sciences. For such a student the discussion of the electron configuration of the elements in Chapter 3 and the use of the Eichinger chart will be upsetting; the use of valence orbitals in Chapters 14, 15 will be frightening; and the discussion of stereoisomerism in Chapter 19 will be completely confusing.

All in all, however, the author has chosen wisely, if this reviewer's interpretation of the aim of this book be correct, and this textbook should prove to be useful and valuable to students who need some understanding of chemistry as a background for courses in nutrition, pharmacology, and physiology. Beyond a few oversights in failing to correct in proof some of the names of organic compounds, (3-methyl pentane and 2,2,3-trimethyl pentane appear as *two* words, for example), there are few misleading or inaccurate statements. This reviewer was somewhat surprised to read under Methods of Science in Chapter 1 that the final step in the scientific method consists of "Accepting a theory established beyond all reasonable doubt as a scientific *law*," however. A theory is not capable of being proved true in the sense that the laws it accounts for are; indeed a theory may or may not be true but what is said about it should be.

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Problems in Inorganic Chemistry

Howard Nechamkin, Trenton State College, Trenton, New Jersey. D. Van Nostrand Co., Inc., Princeton, New Jersey. ix + 169 pp. Figs. and tables. 14 × 21 cm. $3.75.

The title of this little paper volume is most misleading. Each of the first eighteen chapters opens with a several-page review of the topic. The "problems" on the topic follow. The last chapter only includes problems and no text. Furthermore the topics covered include The Nucleus, Crystals, Thermodynamics, and Chemical Kinetics as well as the more usual topics included under the heading of Inorganic Chemistry. In the last chapter a considerable portion of the problems would be better classified as qualitative analysis. It is obvious that the real attempted coverage is much broader than the title professes.

Answers are included to most of the questions; however a spot check of the answers reveals a number of editorial errors and an unfortunate number of factual errors. Unfortunately the same must be said of the text material. A very few examples will suffice to describe what the reviewer finds disturbing.

NH_3 is described as being capable of behaving as either a Lewis or a Brønsted base, while CH_3^- is described as capable of behaving as a Brønsted base only.

Aqueous solutions of copper(I) chloride are written as Cu_2Cl_2 solutions.

N_2O reacts with $NaNH_2$ in one place to produce NaN_3 and H_2O, but in another place to produce the proper products, NaN_3, NaOH, and NH_3.

Lead reacts with fluorine, chlorine, and bromine to form unstable tetrahalides, which release halogen and form colorless PbX_2 salts on heating.

The reviewer has formed the strong opinion that it would be most unwise to use this material with students at any level.

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Chapel Hill

Modern Chemical Kinetics

Henry Eyring and *Edward M. Eyring*, both of the University of Utah, Salt Lake City. Reinhold Publishing Corp., New York, 1963. ix + 114 pp. Figs. and tables. 12.5 × 19 cm. Paperbound. $1.95.

In the paperback series, Selected Topics in Modern Chemistry, several areas of chemistry normally dealt with only briefly in a first-year course have been expanded into little books that can be used as supplements to any standard text. This book is unlike the volumes which have previously appeared in the series: because of the complexity of the subject matter treated, it is "directed chiefly toward upperclass chemistry students rather than those in the earlier college years." This fact is clearly indicated by Sisler and VanderWerf in the Series Editors' Statement.

Eyring and Eyring have undertaken to sketch some of the important developments of the last three decades in the field of chemistry that deals with reaction rates. In order to fit into this series the book had to be so short that the writing of it must have involved its authors in considerable frustration. The number of undergraduate students who have attained the activated state required to appreciate this book is definitely limited. This situation would be impossible to avoid in a book of such brevity dealing with a topic of such depth, breadth and volume. In the preface the authors reveal that their purpose is to infect at least a few readers with "the typical reaction kineticist's enthusiasm for his subject."

The first chapter deals with the origin of the activated state concept and presents briefly the historical development required for proper appreciation of the subsequent chapters. Wilhelmy's study of the rate of inversion of sucrose in 1850 inaugurated the modern era of chemical kinetics. Wilhelmy was the first to formulate correctly the kinetic law of a first-order reaction. The next important step was the proposal by Guldberg and Waage, in several papers appearing between 1864 and 1879, of a Principle of Mass Action in reaction rates and chemical equilibria. In 1877 van't Hoff independently stated the Principle of Mass Action, and in 1889 Arrhenius proposed the hypothesis that molecules must get into an activated state before they can react. This book is concerned primarily with the subsequent development of the activated state concept as motivated by the hope for an *a priori* calculation of the rate of a reaction.

In the second chapter the authors discuss potential energy surfaces in configura-

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tion space and describe the semi-empirical surface devised by H. Eyring and M. Polanyi (1931), mentioning also the modified version proposed by Sato (1955). The third chapter deals with the statistical mechanical basis of rate theory. Topics considered in the fourth chapter include the corrosion of a metal, the smelting of iron, development of the latent photographic image and potentials across biological membranes.

After presenting some basic facts about the bioluminescence of the firefly, the glowworm and the small crustacean *Cypridina*, the authors develop in Chapter 5 the theory of bioluminescence, which has a non-Arrhenius temperature dependence. Absolute rate theory is also applied here to evaporation and condensation.

The sixth and final chapter deals with one of the most important experimental frontiers in present-day chemical kinetics, the measurement of rates of very rapid reactions in solution. Flow methods, competition methods and perturbation methods are discussed. In conclusion, absolute rate theory is applied to fast reactions.

This small volume is thoroughly indexed; and it is excellently printed, even where complicated exponentials abound. References to books and journal articles appear at the end of each chapter. The reader, once he is infected with the authors' enthusiasm, will be pleased to note the existence of such books as "The Theory of Rate Processes" by Glasstone, Laidler and Eyring (1941); "Quantum Chemistry" by Eyring, Walter and Kimball (1944); and "Statistical Mechanics and Dynamics" by Eyring, Henderson, Stover, and Eyring (1963).

LAWRENCE P. EBLIN
Ohio University
Athens

Basic Concepts of Nuclear Chemistry

Ralph T. Overman, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee. Reinhold Publishing Corp., New York, 1963. xi + 116 pp. Figs. and tables. 12.5 × 19 cm. Paperbound. $1.95.

The fifth book to be issued in the paperback series, Selected Topics in Modern Chemistry, consists of material which is "the outgrowth of a series of lectures given to various groups over a period of years," according to the preface to this little book of six chapters averaging 19 pages each. Overman's strong interest in chemical education and his experience as Chairman of the Special Training Division at the Oak Ridge Institute of Nuclear Studies make him well qualified to write for students of chemistry concerning the fields of radiochemistry and nuclear chemistry.

Like the other volumes in this series, Overman's book presents material which is somewhat too extensive for inclusion in a first-year textbook but which should be available to students who wish to make a more thorough study of the particular area with which it deals. The author has developed a concise treatment of the basic principles of nuclear chemistry at the level of the undergraduate student who has some familiarity with scientific concepts and terminology. This includes the most capable of the first-year students.

The first chapter summarizes the structure of the atom and its nucleus and includes a discussion of binding energy. The second chapter discusses alpha particle emission and its explanation in terms of the tunneling effect; excitation of nuclei by neutron bombardment, and processes by which excited nuclei lessen their energy; beta decay, electron capture and positron emission; and radiation background as one of the difficulties in radiation measurements.

The third chapter deals with the interaction of particulate and electromagnetic radiation with matter as the basis for detecting and measuring the radiations. It includes a brief discussion of radiation dosage units and maximum permissible dose.

The fourth chapter considers gas detection and scintillation detection. The basic physics of ionization chambers, proportional counters, and G-M counters is presented with clarity, and there is a survey of the operating principles of scintillation detection systems.

The last two chapters are the most chemical ones in the book. Here are discussed radioactive decay statistics; secular equilibrium; the statistics of counting radioactivity; and applications of nuclear chemistry in fields of fission and fusion weapons, controlled fission and fusion, the production of transuranium elements, the uses of radioisotopes, activity analysis, radiometric analysis, isotope dilution analysis, and activation analysis. Specific applications of interest include the first use of nuclear power in space and the use of isotope dilution analysis as a method for determination of the blood volume of a patient.

It is a pleasure to record that all the volumes which have appeared in this series of small books are well indexed.

LAWRENCE P. EBLIN
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Chemical Calculations

Sidney W. Benson, University of Southern California, Los Angeles. 2nd ed. John Wiley and Sons, New York, 1963. xii + 254 pp. Figs. and tables. 15 × 22.5 cm. Paperbound. $2.95.

The first edition of this book, published in 1952, emphasized the logical application of the conversion-factor method to problem solving in general chemistry. In the past decade, this approach has attained almost universal acceptance. Much of the credit for the trend away from "cookbook" methods of solving mathematical problems must go to Professor Benson. Despite a higher level of competition, the book remains a classic in its field.

The second, paperback edition represent an addition to rather than a revision of the first. All of the problems have been retained; about 100 more, principally of a more advanced nature, have been added. The explanatory material, except for a short section on acid-base equilibria in Chapter 13, is repeated verbatim from the first edition. Brief discussions of the molar heat capacity of gases (Chapter 6), successive equilibria (Chapter 10), Brønsted acids and bases (Chapter 12) and half lives (Chapter 17) have been grafted on to the text. The properties and reactions of substances are outlined in two new appendices.

It is unfortunate that the author continues to use the terms "molecule" and "molecular weight" with reference to such compounds as sodium chloride. One might also wish for a more consistent use of ionic as opposed to molecular equations. With these reservations, the book can be recommended as a particularly lucid treatment of the mathematics of general chemistry.

WILLIAM L. MASTERTON
University of Connecticut
Storrs

General Chemistry

William H. Nebergall, and *Frederic C. Schmidt*, both of Indiana University, Bloomington, and *Henry R. Holtzclaw, Jr.*, University of Nebraska, Lincoln. 2nd ed. D. C. Heath and Co., Boston, 1963. viii + 791 pp. Figs. and tables. 19 × 23.5 cm. $9.25.

The second edition of this text is an extensive, thorough revision which brings the book up to date while retaining the basic organization and features of the first edition (reviewed in J. CHEM. EDUC., **36**, 637 [1959]). An excellent chapter on coordination compounds has been added, reflecting the research interests of the new third author, Dr. Henry F. Holtzclaw, Jr. This chapter includes a brief introduction to the Ligand Field Theory. The chapter on Colloids has been strengthened in accord with present-day work in synthetic polymers and protein chemistry.

Other modernizations include new or expanded sections on atomic orbitals, atomic weights based on carbon-12, and use of the terms "Celsius" instead of "centigrade" and "rare gases" instead of "inert gases." Many new industrial developments are described, such as the De Nora cell for the production of sodium hydroxide, the synthesis of diamonds, the ion engine, rocket propellants, semiconductors, solar batteries, fuel cells, and breeder reactors.

The authors set an excellent example in problem solving. The factor and molar methods are used throughout to minimize memorization and substitution in formulas Happily, there is not a single P, V, or T substitution formula in the entire chapter on The Gaseous State. The appendix includes useful sections on exponential arithmetic, logarithms and the solution of quadratics. Units and dimensions are

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carefully included with all sample problems and the authors follow the advice of their own section on significant figures.

End-of-chapter review questions and problems have been revised and supplemented, with answers included for all numerical problems. The lists of references to readily available recent literature should be helpful to instructors as well as to students.

The text appears to be relatively free from errors although it still ascribes the motion of a paddle-wheel Crookes tube to straight momentum transfer instead of in terms of the radiometer effect. (See THIS JOURNAL, 38, 480 [1961]).

The book is attractive in format, distinctive in its purple color, and liberally illustrated. The inside of the dust jacket has a handy Table of Atomic Weights and a Periodic Table both based on carbon-12 and suitable for display or reference purposes.

In summary, this book is worthy of consideration as a text for traditional first year courses in college chemistry. It has good balance between descriptive and theoretical chemistry. The 46 chapters provide sufficient material to allow the instructor to select portions fitted to the special needs of his classes.

ALBERTINE KROHN
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Programed Instruction for Schools and Industry

J. L. Hughes, International Business Machines Corp., Science Research Associates Inc., Chicago, 1962. xv + 299 pp. Figures. 18 × 25.5 cm.

A Guide to Programmed Instruction

Jerome P. Lysaught and *Clarence M. Williams*, University of Rochester, Rochester, New York. John Wiley and Sons, Inc., New York, 1963. xi + 180 pp. Figures. 14.5 × 22 cm. $3.95.

To this reviewer's knowledge all teachers who have prepared two or three programs on selected topics for their own students have remarked upon the dramatic increase in their own ability to teach any other topic more effectively. It can safely be assumed that this phenomenon is universal, provided that the teacher prepares, and revises, programs for, and with, his own students. However, before this can be effectively accomplished, some instruction in the art of programing is essential. Until recently, though there have been several reference works available which claimed to help a teacher learn how to construct programs, only one outstanding work could safely be recommended. That book, "Teaching Machines and Programmed Learning," edited by A. A. Lumsdaine and R. Glaser, Department of Audio-Visual Instruction, National Education Association, Washington, D. C., 1960, is still recommended to all who are interested. For a general introduction to the field, "Teaching by Machine" by L. M. Stolurow, U.S. Office of Education, HEW, Supt. of Documents, Washington 25, D. C., 1961, is probably the best available. Now, two more books, those under review here, can be added to this list. With these, at least for the next few years, the necessary references are now completely available.

Hughes' book is an introductory text. It, with that of Stolurow, can be strongly recommended to any teacher or industrialist who wishes to know what programed instruction is, and something about its elementary details. Specifically, after defining programed instruction by means of examples from selected sources, Hughes discusses the detailed means by which one begins to write, and revise, a program on any selected topic. Hughes also includes much useful material in six appendices, though Appendix A, listing commercially available programs, was necessarily out of date before the book was published.

Lysaught and Williams discuss the art of program construction in much greater detail, extending their very helpful examples into those areas which deal with refinements of the items (frames) in a program. Since Hughes only treats this lightly, if at all, Lysaught and Williams complements the work of Hughes almost ideally. Because they are somewhat slow in getting to the real points to be discussed, Lysaught and Williams may be boring to some readers who are anxious to learn the details. However, the background which is discussed first is necessary, and a careful study of the first five chapters will make the last four more effective.

Both books discuss linear and intrinsic programing, though Hughes stresses intrinsic programing more.

Probably in an effort to address their books to two somewhat different audiences, teachers, and industrialists, the authors of both books have perhaps overstressed the advanatages of programed instruction as a tool which eliminates the need for teacher-time in instructional activities of a routine nature. Unquestionably, this use constitutes an important advantage of programed instruction. However, a far greater advantage of programed instruction lies in its use as a means of improving the teacher's skill as a communicator, when programed instructions are written, and revised properly. This advantage, alone, justifies the current excitement about programed instruction.

Finally, probably because the value of programed instruction was first recognized by behavioral psychologists, these books, as well as others which deal with programed instruction, seem by implication and outright statement to imply that man learns by a process, which differing only in degree and not in nature, is similar to that by which lower animals learn. Hence, both books being reviewed emphasize, as part of the art of programing, certain techniques, such as gradual fading of a stimulus, the excessive importance of reinforcement, and other special devices. To be sure, man does learn, in part, as any other animal learns. But beyond this, because he is different in nature from all other animals, man can learn in other ways. Neither of these two books stress the importance of challenging the student occasionally, neither indicates emphatically that man can learn by being asked to think. Both seem to imply that man can learn only if he is told.

Many chemistry teachers have reacted adversely to this implication which they have, properly, imputed to some programed instructions in scientific topics prepared by behavioral psychologists. Fortunately, this rote learning approach need not be characteristic of programed instruction. Programs, particularly in chemistry, are being prepared which do challenge the student to think occasionally as he threads his way through the list of ordered questions and answers.

With the otherwise decidedly helpful assistance provided by the two books being reviewed here, perhaps more chemistry teachers will be stimulated to prepare more programs.

JAY A. YOUNG
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Chemistry 1: Atomic Structure and Bonding: A Basic Systems Program

Edited by *Charles R. Dawson*, Appleton-Century-Crofts. Lyons and Carnahan (affiliates of Meredith Publishing Co.), New York, 1962. xi + 273 pp. 15 × 22.5 cm. Paperbound. $3.24.

Chemistry 1. Response Book

84 pp. $0.64.

Chemistry 1. Teachers Manual

iii + 44 pp. No charge.

The program which is the subject of this review is the first to be published by a regular textbook publisher; it is the product of Basic Systems, an organization of professional program writers. The subject matter covered is the usual text material on the structure of atoms (protons, neutrons, electrons, electron shells), the periodic table and the regularities of structure as a function of position in the table, electronegativity, and bonding (ionic, covalent). While the program is designed for high school, it could find some use in college classes as well.

The student who goes through this program will have learned all this material thoroughly if he is capable of learning it at all.

There is a picture or diagram in nearly every frame, so the student has no page flipping to do to find material referred to. There is plenty of repetition; not only at once, but all through the program the student uses and reuses the material learned earlier, so that the program emerges whole, with no chance that the reader has forgotten the beginning when he gets to the end. This repetition and practice are admirably and skilfully done.

The teacher who looks at the program for the first time will probably react negatively; but the teacher who bothers to work through the program for an hour will be convinced of its effectiveness.

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Each frame, or step, is tiny, but the longest journey begins with a single step. Here the steps are not only consecutive so that there is no trouble following, but the repetition and practice appear at such intervals that one gets the impression the program was woven, and the ideas emerge as a single fabric.

The very facts which make a program successful will also make it appear at first glance as something "too simple." The clarity and exact statement and brevity of each frame also make that frame very easy indeed to criticize, but the ease of criticism results from its being immediately clear and understandable.

A Teachers Manual of 44 pages is meant to be used as the students go through the text. The Manual begins with a discussion of program design and how to use the program. Data is then given on the test performance of 12 students who worked through the finished program, to provide a guide as to what the teacher can reasonably expect in the way of student performance. This is followed by 10 lesson plans, with suggested reading assignments in standard texts for the students, topics to discuss and how to discuss them for the teacher, and suggested experiments in detail to illustrate various ideas in the program. Drill material, reference data, and suggested tests are included.

As the art of programing develops, better programs will be written, but none more skilfully. This program is of the linear type, and has all the faults and strengths that go with linear programing.

JESSE H. DAY
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Physical Science: A Study of Matter and Energy

Verne H. Booth, Brooklyn College, Brooklyn, New York. The Macmillan Co. (a division of the Crowell-Collier Publishing Co.), New York, 1962. xv + 713 pp. Figs. and tables. 19 × 23.5 cm. $7.95.

Since the introduction of survey courses in physical science, there have been almost as many different approaches and emphases as there have been courses offered. Dr. Booth begins, as many others do, with astronomy. He follows with physics, chemistry and geology in that order. To each of these respective fields he devotes approximately 15, 35, 35, and 15% of the text. In his preface he states his main purpose: to achieve continuity and "the highest degree of integration." In this undertaking which amounts to paying out "the continuous thread that holds the course together, gossamer though it may often be," he has been largely successful. Concerning the problem of integrating fundamental geological processes he admits frankly that "there is no good way to do it." "Matter and Energy," as embodied in the title, become the integrating theme.

In fact, he may have gone a little too far, as he writes: "Another primary objective has been that of clarity, many of the concepts of physical science . . . [are] presented at the level of the non-science major." This attempt appears to have led to an approach too unsophisticated for the college student who has already had one or two courses in physical science.

The chapters given to chemistry emphasize the principles and theories and minimize "descriptive chemistry." The chapter titled The Chemistry of Carbon with its outline of organic chemistry could be called descriptive, and one wonders how much of it would be normally retained.

Although he makes a point of using the atomic weight scale based on carbon-12 "in a text book for the first time," the author unfortunately did not use this scale in his Periodic Table. At one place he uses the upper left corner for the mass number accompanying symbols of elements but reverts to the upper right when discussing isotopes.

In spite of such minor inconsistencies as have been cited, this book is one of the better texts in this field for the above-average student.

EDWARD M. COLLINS
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Granville, Ohio

Infrared Spectra of Inorganic and Coordination Compounds

Kazuo Nakamoto, Illinois Institute of Technology, Chicago. John Wiley and Sons, Inc., New York, 1963. xii + 328 pp. Figs. and tables. 15.5 × 23.5 cm. $9.50

The author appears to have made a comprehensive review of the literature of the infrared investigations of inorganic and coordination compounds. Over 1000 references are cited. The book consists of three parts and five appendices, and contains 73 tables and 74 figures and illustrations.

The first part presents a minimum amount of the theory of vibrations and normal coordinate treatment. Symmetry elements and point groups, selection rules and an introduction to group theory are discussed.

The second part covers the infrared spectra of inorganic compounds from XY to XY_6 molecules. The classification in this section is based on the symmetry and point groups of the molecules. Tables and several typical spectra complement the written discussion.

The third part compiles the infrared data of coordination compounds. The classification in this section is based on the kind of ligands involved in the complex. Again many tables and spectra are presented.

The five appendices consist of Point Groups and Their Character Tables, The G and F Matrix Elements of Typical Molecules, A Normal Coordinate Treatment of Metal Acetylacetonates, A Conversion Table for Wave Number and Wave Length, and Group Frequency Charts. All appear very useful, although the appendix on normal coordinate treatment of a complex molecule such as a metal acetylacetonate might be too advanced for beginners. A treatment involving simpler molecules might be of more general interest.

The book is very well organized, and is a distinct improvement over previous books on this subject. It will be of interest to spectroscopists and inorganic chemists, and will be very valuable as a reference or for supplemental reading in graduate and advanced undergraduate courses.

JOHN R. FERRARO
Argonne National Laboratory
Argonne, Illinois

Physical and Chemical Methods of Separation

Eugene W. Berg, Louisiana State University, Baton Rouge. McGraw-Hill Book Co., Inc., New York, 1963. Figs. and tables. xiv + 366 pp. 16 × 23.5 cm. $12.50.

The author has accomplished his goal of assembling material suitable "for a course in separation techniques to be taught at the advanced undergraduate and beginning graduate level in chemistry." The breadth of the coverage is indicated by the chapter headings: Introduction; Fractional Distillation and Sublimation; Liquid-Liquid Extraction; Adsorption Chromatography; Gas Chromatography; Paper Chromatography; Electrochromatography (Zone Electrophoresis); The Ring-Oven Technique; Zone Melting; Ion Exchange; Ion Exclusion; Dialysis; Electrodialysis and Ion-Exchange Membranes; Precipitation; Coprecipitation, Adsorption and Postprecipitation; Flotation; Biological Methods; Elimination of Undesired Reactions Through Use of Sequestering (Masking) Agents.

The author briefly attempts to justify the order in which he treats the subjects, largely on an operational basis. Those who might disagree will find that each chapter can stand quite well by itself. It did come as a surprise to find adsorption being defined and properties of surfaces being discussed in detail for the first time under flotation when an understanding of these topics was required for earlier chapters (4 and 15). An expert within a particular discipline will undoubtedly feel unhappy to find his specialty limited to an average of 20 pages. For example, the important contribution of Rieman and coworkers with respect to calculation of the minimum number of plates required for a given ion-exchange separation is not included. The pressure for brevity has also led the author to omit necessary qualifications of his statements. For example, on p. 69 he indicates that a solute in a Craig-type counter-current extraction follows the normal curve of error when the number of tubes is greater than 25. Such a statement is, of course, dangerously misleading if the distribution coefficient is not close to unity. Likewise, the term R_f is defined

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in two (inconsistent) ways on pp. 82 and 115, the latter now being generally preferred. Despite such shortcomings, the book provides an excellent introduction to a wide variety of techniques. It will be most useful to students and to "practicing chemists who are unfamiliar with the more recent innovations in the field of separations."

LOCKHART B. ROGERS
Purdue University
Lafayette, Indiana

Topics In Chemical Physics: Based on the Harvard Lectures of Peter Debye

Alfred Prock, Boston University, Boston, Massachusetts, and *Gladys McConkey*, Cornell University, Ithaca, New York. American Elsevier Publishing Co., Inc., New York, 1962. vi + 277 pp. Figures. 15.5 × 23.5 cm. $11.

Attending a lecture by Professor Debye is an experience similar to the hearing of a great concert artist for a music lover. Having a well transcribed set of lecture notes for his Harvard Lectures is like having a good recording of the concert. The authors of this book have performed a useful service to the reader in capturing the beauty, simplicity and physical insight of Debye's presentation.

The lectures cover most of the fields of Debye's important contributions in studies of polar molecules in gaseous and condensed phases, diffraction and scattering and solutions of electrolytes. They do not discuss contributions to the statistical mechanics of solids. The level of presentation is suitable for chemistry and physics seniors and first year graduate students and is characterized by Debye's intuitive approach in which liberal use is made of physical reasoning to ease the way past difficult mathematics. This approach, while satisfying to the beginning student, is also gratifying to the experienced scientist in its providing insight into the reasoning processes of a great master. Those wishing more complete derivations will find the many appendices of value. Many subjects, such as the Onsager and Kirkwood theories of dielectrics and theory of light scattering from porous solids are presented in a very readable form not easily found elsewhere and not usually covered in graduate curricula.

A minor defect is found in the mathematical typography. The choice of symbols is not always best. For example, it would have been better to use boldface type for vectors.

The book should prove useful both for a "special topics" course and for supplementary reading for the graduate student, advanced undergraduate and practicing physicist or chemist, and is a welcome addition to personal library of those wanting a first hand report on the contributions and techniques of one of the founders of chemical physics.

RICHARD S. STEIN
University of Massachusetts
Amherst

Physical Chemistry

Walter J. Moore, Indiana University, Bloomington. 3rd ed. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962. xiii + 844 + xxv pp. Figs. and tables. $13.

The appearance of any undergraduate chemistry text in its third edition almost automatically classifies it as one of the "standard" texts in the field, and "Physical Chemistry" by Walter J. Moore certainly belongs in this category. Since it seems quite likely that most North American physical chemists are at least cursorily familiar with the earlier editions, the revisions in the present edition are a point of immediate interest.

The present volume represents a rather complete reworking of the seven-year old 2nd edition, accompanied by a substantial expansion of the total amount of material (872 pages vs. 633 in the 2nd edition). A chapter on High Polymers represents the only really new topic treated in detail, but the former chapter on the Structure of Molecules has been approximately doubled in size and is now contained in two chapters on the Chemical Bond and Molecular Structure and Molecular Spectra. Similarly, there are now two chapters on electrochemistry, containing together about 50% more material than the single chapter in the 2nd Edition. The chapters on Particles and Waves and on Crystals, now titled the Solid State, have also been expanded by nearly half in the revision. Several changes have been made in the order of presentation of the material.

The illustrations have been redone; the book has been printed with high quality, and is physically thinner than the previous edition. More problems have now been included (more than 560 in total); relatively few of the problems from the 2nd edition reappear here. Needless to say, the price has expanded, too, but the present price of $13.00 is reasonably competitive with the other texts available for undergraduate physical chemistry.

This edition has the chief advantages that have been associated with the earlier editions of Moore—fresh and interesting writing, complete coverage of almost all topics appropriate to a course in undergraduate physical chemistry, and a good introduction to those topics of chemical physics whose rigorous development can then follow in graduate work.

The book is now long enough that some material must surely be omitted in a two semester course—nevertheless, the material is there for the choice of the instructor, and for the outside reading of the inquiring student.

The comment has often been made that Moore's book is fine for the top students, but very hard for average studeuts. In my own experience, some of these "average" students have commented very favorably about the clarity of the explanations that they found in Moore.

This text certainly merits strong consideration for all undergraduate physical chemistry courses.

F. S. ROWLAND
University of Kansas
Lawrence

Collection of Problems in Physical Chemistry

Jiri Bares, et al. Translated by *Helena Watney*. Pergamon Press, Ltd., Oxford, 1962. xvii + 608 pp. Figs. and tables. 16.5 × 23.5 cm. $9.75.

There have been a number of changes in the standard physical chemistry course over the last few years, involving chiefly a much greater emphasis on theory with a corresponding de-emphasis of the empirical physical chemical relations. Physical chemistry, however, has always entailed a great deal of problem solving. Thus, this book and the one in the following review will no doubt be of interest to students and faculty members engaged in this field.

This book is an attempt, as the authors point out in the preface, to cover the whole field of physical chemistry. The result is a large book which may be beyond the size or the price range of those whose interest in the field is temporary. It is divided up into eleven chapters, each of which consists of some 10 to 20 problems, with method of solution and brief discussion, followed by a number of problems to be solved. The answers to the problems are given at the end of each chapter. The example problems are in general taken from the literature with references cited; in the remaining problems, however, the data are for the most part presented without reference.

The book is a translation of a Czech text which, for the most part, leads to no great difficulty. Unfortunately, since the original text was written before 1960 the atomic weights and physical constants used are those based on the chemist's (0 = 16.000 g/mole) scale, except for the parts on nuclear chemistry which use the old physical scale. There are, however, a few very real problems which the American reader may find. The authors claim to have used the recommendations of the Stockholm convention which is to their credit, but they have failed to include a table listing the symbols and definitions used, and since all the recommendations of the Stockholm convention are not in general use in this country, possible difficulties may be encountered. Perhaps the thing which will cause the most confusion is the use of European conventions with regard to the Gibbs and Helmholtz energies. For the Gibbs energy, for which American convention is now changing the symbol from F to G, this book uses the symbol G but calls the function the free enthalpy; for the Helmholtz energy (American, A, work function) they use F and the designation free energy. Another source of confusion is in the matter of cell conventions. The table of potentials at the end of the book is in agreement with the Stockholm convention (reduction potentials); however, in the text itself no consistent scheme seems to have been followed. The problems use both oxidation and reduction potentials, thus not following the Stockholm recommendations, though in general the authors are careful to indicate what it is they are dealing with.

(*Continued on page A669*)

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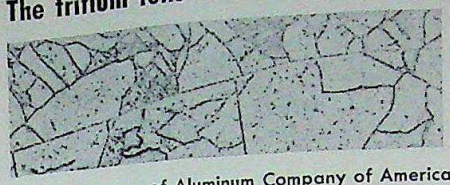
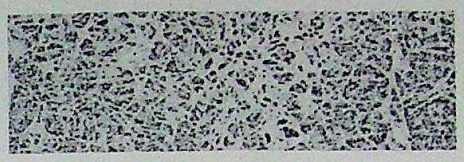
Kodak reports on:

a kind of metallurgical autoradiography . . . hybridized orbitals in the news

The tritium tells





Courtesy of Aluminum Company of America, which, in a paper in *Nucleonics* this April that describes this technique for precipitating tritium to delineate defect structures in solids, says, "Eastman Kodak Company 1 x 3 in. Autoradiographic No-Screen nuclear plates are employed exclusively," which is a kind and probably useful remark to make publicly. It certainly justifies our offering free reprints of their paper on request to Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y.

Zone-refined aluminum (×6.5). Only the continuous diagonal grain boundary was visible until tritium precipitated where vacancies have condensed . . .

. . . whereas after severe strain and annealing, vacancies migrate out of the cell boundaries and no longer collect tritium . . .

. . . but the tritium sure shows the dislocations piled up at slip bands of an aluminum tensile specimen.

Opium and europium

The core of the following message is simply that Distillation Products Industries, Rochester 3, N. Y. (Division of Eastman Kodak Company) stands ready, willing, able, and anxious to supply professionally prepared persons with any of a vast array of compounds, as detailed in "Eastman Organic Chemicals List No. 43," obtainable on request.

Many years ago it was a practice, when investigating the possibility that a victim had been drugged, to test the contents of suspicious vials with Marme's Reagent. This threw down a yellowish-white precipitate with salts of alkaloids.

Papaver somniferum, the opium poppy

Opium was known to be rich in alkaloids. They were defined as organic substances of alkaline nature. As time went on, fences were erected against this sweeping generality. Not mere alkalinity *per se* but precipitation by certain inorganic "alkaloidal reagents" was required to qualify as an alkaloid. (Concepts can shrink by swallowing their tails.) One such was apparently devised by somebody named Marme from KI and CdI_2. We doubt he knew why a precipitate formed by this concoction correlates with the dream world. (Neither do we, but we have to appear more knowledgeable.)

When a request for Marme's Reagent was received recently, we consulted an old chemical dictionary to find out what it was. Then we put a 1963 orientation on the matter.

In 1963 chemists can't afford to make their own reagents unless they happen to be in the reagents business, which we are. So we made Marme's Reagent, but we don't think of it that way. We offer it as a dry compound named *Potassium Iodocadmate* (EASTMAN 8814). We think of it not as $CdI_2 \cdot 2KI$ but as $K_2^+[CdI_4]^=$. We see that cadmium ion with its four hybridized orbitals (from the 5s and the three 5p orbitals) coordinating to the four iodides, and we see that $[CdI_4]^=$ ion forming its precipitate in response to the electron-hunger of the heterocyclic nitrogen that gives the "alkaloids" their alkalinity. We look around a little and note that while Marme's name is little heard any more his ion is still talked about for identifying amines, imines, and heterocyclic N's in general, judging from an excellent review of chelatometric quantitative organic analysis in *Chimie Analytique*, *43*, 449 (1961). We also note that EASTMAN Organic Chemical No. 8814 is not very organic, but it does not upset us.

The coordinate-bond chemistry arising in those hybridized orbitals is now leaping the walls of its old temple, the analytical laboratory. Suddenly there is a lot more to be said about fluorescent chelates than that they are useful for the determination of something or other. Let us merely record that

1) it has not escaped the notice of the Kodak Research Laboratories (which are strongly optically oriented) that the rare earth ions in general and Eu^{+3} in particular exhibit very sharp fluorescence lines because the 4f subshell involved is well shielded by the 5s and 5p subshells

2) this fluorescence leaves the ion in a state from which it drops so quickly to ground state that the jump-terminating level remains thinly populated

3) here is the kind of setup wherein the stimulated emission of laser action can compete successfully against the spontaneous transitions of fluorescence and absorption

4) the lifetime of the upper state is not too short to achieve a good inversion and not too long to retain the inversion while waiting for action to commence

5) chelating the rare earth ions shields them from influences that might prematurely discharge the inversion

6) the ligand of the chelate absorbs over a broad u-v band and passes the energy along from its own metastable triplet states to excite the 4f levels of the rare earth ion

7) *Tris(1-phenyl-1,3-butanediono)europium* is now EASTMAN 8989, *Tris[4,4,4-trifluoro-1-(2-thienyl)-1,3-butanediono]europium* is EASTMAN 8990, and *Tris(1-phenyl-1,3-butanediono)cerium* is EASTMAN 8629

and 8) anybody finding himself in a state of personal excitation over any ligand-lanthanide combination (except Pm) has but to name it and he may find we have a little on hand.

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

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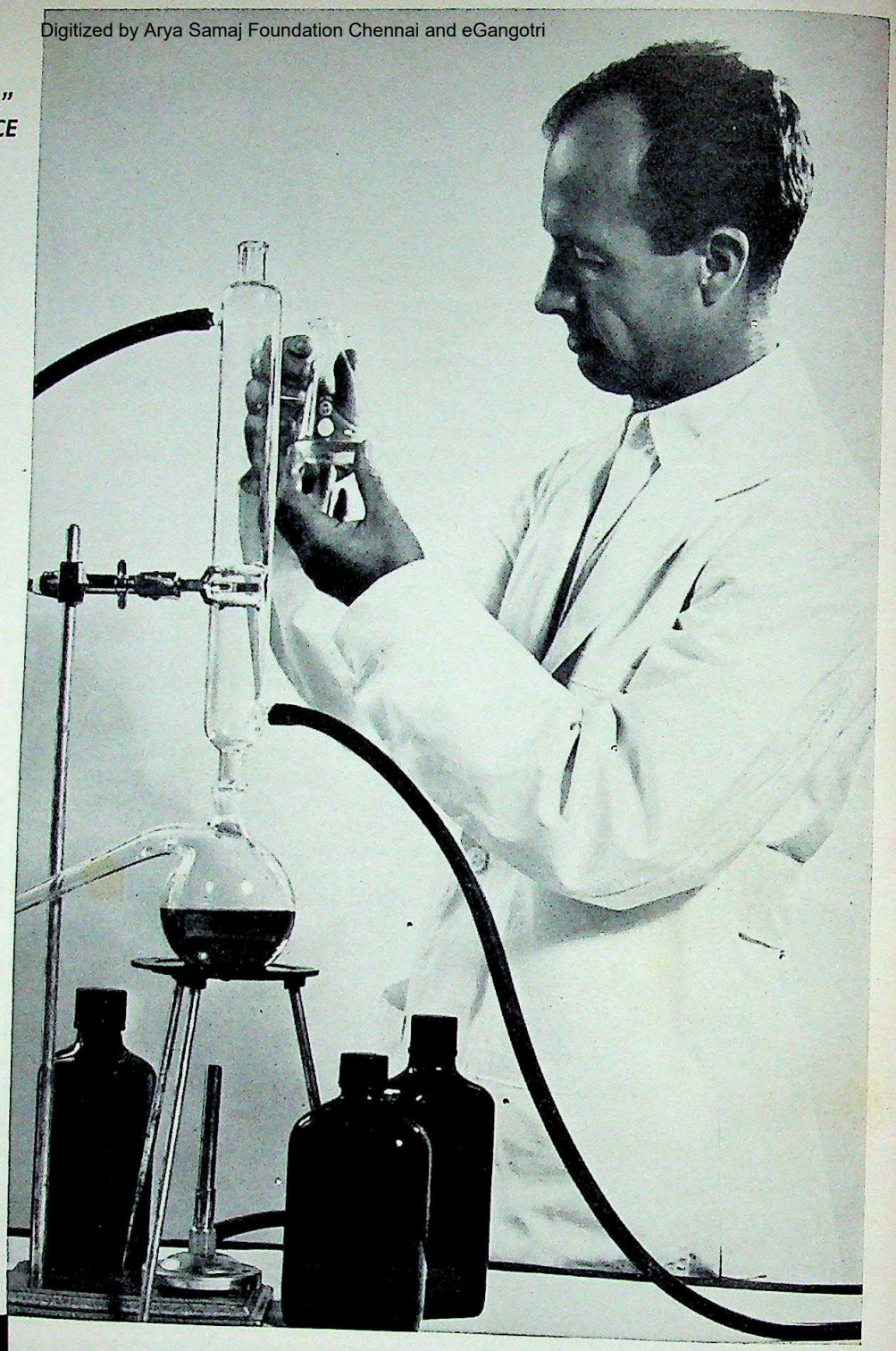

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BOOK REVIEWS

The general approach of the book seems to indicate a greater interest in the mechanics of problem solution rather than emphasis on the basic physical chemical principles. This is not in keeping with the modern trends in the field in this country. The well-known book by Sillén, Lange and Gabrielson, is, in general, better in this respect. This aspect may best be illustrated by the first of the example problems on solids. The problem gives data stating that triaza-adamantane crystallizes in face-centered lattice which they say has a multiplicity (number of molecules per unit cell) of 2. They then present data for the measurement of the 10th line in the Debye-Scherrer powder diagram which they say results from reflections of the planes with Miller indices $(hkl) = 123$. The resulting density which they calculate agrees well with the measured density. However, the actual crystal is body-centered cubic, a fact which they seem to use in the solution. Thus "face-centered cubic" may be merely an error in translation. Nevertheless, the reflection from the 123 planes will be the 7th rather than the 10th line for a body-centered lattice, the 13th for a simple cubic lattice and would not even appear in a face-centered diffraction pattern because of systematic extinction. It is only fair to say that this is the only instance of this sort noted, yet it serves to illustrate the general approach and concern of the authors.

This book is valuable for the vast variety of problems with experimental data which it contains but should be used with some caution in areas where one does not have a basic understanding of the underlying theory.

James H. Loehlin
College of Wooster
Wooster, Ohio

Ion Exchange Separations in Analytical Chemistry

Olof Samuelson, Chalmers University of Technology, Göteborg, Sweden. Almquist and Wiksell, Stockholm, and John Wiley and Sons, Inc., New York, 1963. 474 pp. Figs. and tables. 15.5 × 23.5 cm. $9.50.

This is advertised as a new book rather than a new edition of the author's "Ion Exchangers in Analytical Chemistry" published in 1953 and reviewed in THIS JOURNAL 30, 596 (1953). The author has retained the same organization as in the earlier book but has enlarged, revised and updated the material presented in each section. The bibliographies for all sections seem quite complete for papers published through 1961, and include a great number of foreign-language papers not generally available in this country.

The Introduction is virtually unchanged in content and length (11 pages) from the first book. The General Part has been expanded from 59 to 120 pages. Major additions have been made in the section entitled Fundamental Properties, including some material concerning chelating resins and the sorption of complex ions. The section on Ion-Exchange Equilibria is more complete, and now contains a detailed discussion of equilibrium at trace concentrations. The mathematical treatment is elementary and designed for the practical use of analytical chemists. Kinetics and Column Operation are again given only cursory treatment. One of the most important additions to the new book is a 13-page discussion of Applications of the Plate Theory, which explains the simplest way to calculate separation conditions after a minimum of preliminary experiments. This part ends with a discussion of Non-Aqueous Solutions, a topic completely ignored before.

The Practical Part treats in 85 pages (increased from 45) the techniques for choosing the proper resin and performing ion-exchange and ion-exchange-chromatographic separations. The methods described are those developed in the author's laboratory over the past 30 years. Refined techniques which have become important since the earlier book are described. These include gradient elution, methods for continuously analyzing column effluents, and the use of ion-exchange resins as precipitants. Only column and batch procedures are considered; ion-exchange paper chromatography and thin-layer ion-exchange chromatography are barely mentioned in two concluding paragraphs.

The heart of the book is the section on Applications. This part has been increased from 144 to 197 pages, but now is restricted entirely to separations important in the analysis of inorganic substances. Considering the many analytically important separations of organic substances which have been developed on ion-exchange columns, especially during the past decade, it seems unfortunate that the author chose to ignore this area.

In most cases the procedures are only briefly summarized, in the expectation that those interested in specific separations will consult original research papers. Detailed descriptions of a few specific applications developed in the author's laboratory are included for those completely unfamiliar with the field.

The appendix contains a description of commercially available ion-exchange resins. The book is conveniently indexed according to author and subject.

Recently, a number of books on ion exchange and several treatises of analytical chemistry or chromatography containing chapters on ion exchange have been published. For the chemist who wants to have one of these in his library, this book is recommended. It is a well-written, authoritative, understandable, although not exhaustive source of information for teachers wishing to incorporate material on ion exchange in their courses (especially analytical courses) or for chemists beginning experimental work in the field. Those with an established interest in ion exchange can find more thorough, rigorous treatments of the subject, but will want this volume if only for reference, especially to the research work of its eminent author.

Joseph Sherma
Lafayette College
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Theory and Applications of Ultraviolet Spectroscopy

H. H. Jaffè and *Milton Orchin*, University of Cincinnati, Cincinnati, Ohio. John Wiley and Sons, Inc., New York, 1962. xv + 624 pp. Figs. and tables. 16 × 23.5 cm. $15.

A book reviewer is very cognizant of the time and effort the authors have contributed to produce a work useful to others—time and effort that the reviewer himself would be unwilling and perhaps unable to contribute himself. This is especially true of the book under review, for it is obviously monumental in scope, covering the range from abstruse theory to mundane practice with a detail that is sometimes astonishing. And it is attractively produced, well and profusely illustrated.

Yet time and again, the treatment falls just short of being completely authoritative, engendering a sufficient amount of mistrust to lower the general value of the book to an unfortunate degree. At first glance it clearly gives the impression of being both encyclopedic and sound, but closer persual suggests that the treatment leaves much to be desired.

Thus we can read that "digonal hybridization *makes* acetylene a linear molecule" (italics ours), that the "MO treatment must, by its nature, start from atomic *one-electron* orbitals" (sic!). "The VB method, on the other hand, can start from atomic functions of any degree of complexity." We can see a perspective representation of the *bonds* in acetylene which is clearly noncylindrical (despite a statement to the contrary in the text). Even as simple a concept as orthogonality is quite incorrectly defined in the glossary. And we can read on p. 546 that "in fluorescence there is a relation between the absorption and emission spectra, the mirror law, but in phosphorescence no such relation exists." But five pages later we find, "accordingly the same mirror law applies [to phosphorescence]."

These are but a small sample of many that can be found readily. They are unlikely to bother the *cognoscenti*, but then such a book need not be written for them. The uninitiated, however, may be severely misled by such mistatements.

Lest one gain the impression, however, that the volume is without merits, let us call attention to the fact that it is a splendid source of references from which to start a search of the literature in a given area. And many areas are considered in detail. Besides the theoretical section which occupies perhaps a third of the book, there are separate chapters on solvent effects, the conjugated dienes, polyenes and the free-electron model, benzene and derivatives, polycyclic hydrocarbons, heterocycles, steric effects, organic radicals and ions, compounds of sulfur and phosphorus, inorganic complexes, and one on fluorescence and phosphorescence. The book ends with a chapter on applications of spectra to quantitative analysis and on the determination of equilibrium constants which seems somewhat out of place.

Although the material presented is extensive, there still is a great deal not included. There is nothing on the vacuum region, on Rydberg transitions, on high resolution gas phase spectra, on experimental techniques, practically nothing on polarization of transitions, or on crystal spectra. And nothing so far afield as optical rotatory dispersion, magneto-optic effects, etc. is mentioned.

In summary we can say that although this impressive volume will have considerable utility to those active in the field as a general source book, it is of debatable value to elementary students of the field or as a text. There still seems to be a need for a really authoritative survey of this important area.

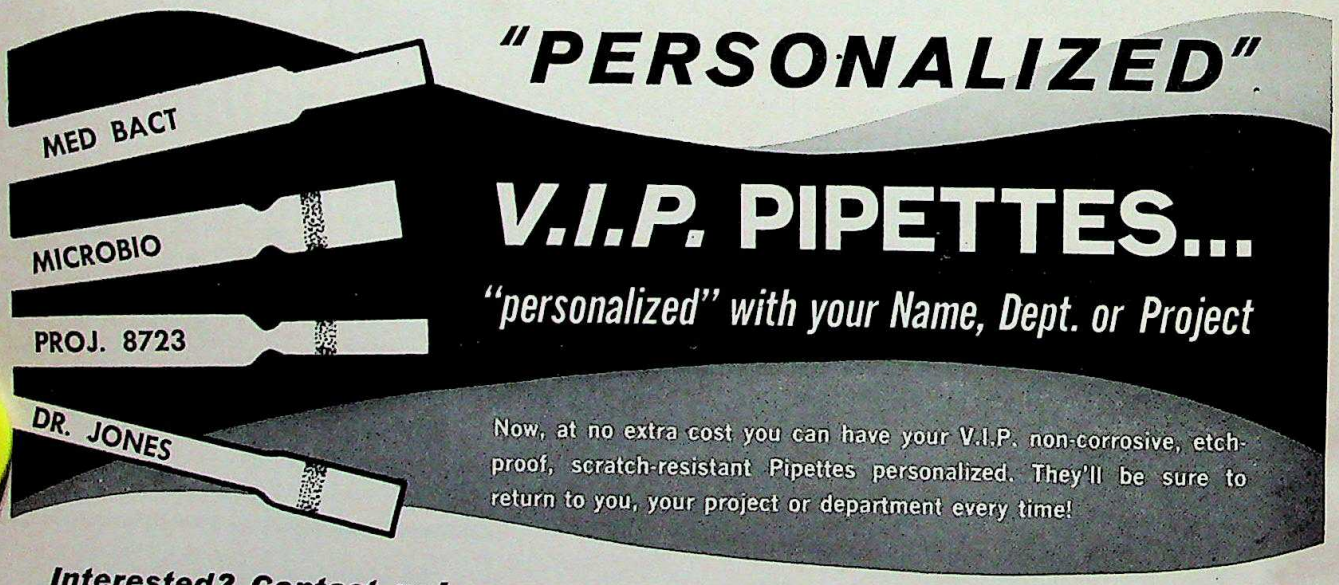
HARRISON SHULL
Indiana University
Bloomington

Textbook of Polymer Science

Fred W. Billmeyer, Jr., University of Delaware, Newark. Interscience Publishers (a division of John Wiley and Sons, Inc.), New York, 1962. xiv + 601 pp. Figs. and tables. 16 × 23.5 cm. $12.75.

"Polymer Science" covers a multitude of specialties from the purely physical

(*Continued on page A671*)



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measurements of the mechanical properties of polymers or of their dilute solution properties, to the purely organic reactions of polymer synthesis, to the design engineering of polymer application and the mechanical engineering of polymer processing. Any single volume that attempts to cover such a wide field must of necessity be primarily an outline, as is the present one. One can find sections relating to almost any desired topic in the field of polymer science including quite recent ones such as the study of polymer single crystals, coordination polymerization, differential thermal analysis, etc. Under each entry will be found a brief, usually good, introduction to the area, but not extensive detail. It is the intention of the author that this detail be filled in by the reader by making use of the extensive general and specific references which accompany each section.

In any outline the organization of the material is most important and in this respect Dr. Billmeyer has succeeded well. After a brief historical survey he first discusses the physics and physical chemistry of polymers as they relate to structure and properties. The coverage is good and complete.

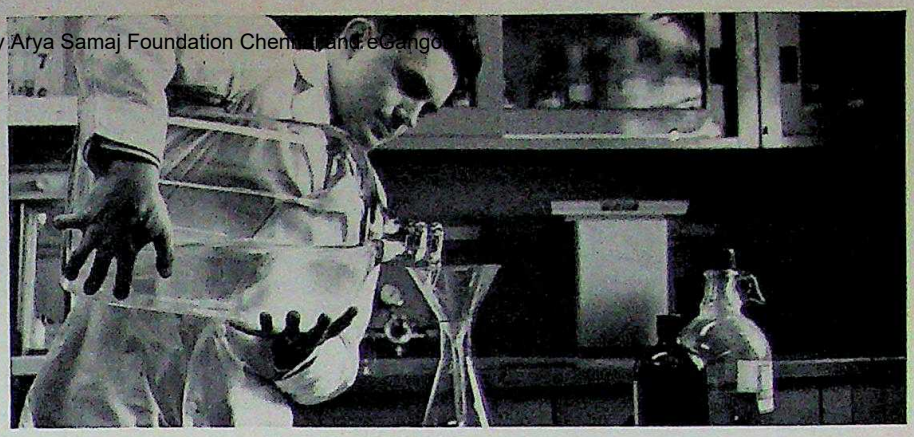
Chapter 5, Morphology and Order in Crystalline Polymers, has some very striking photomicrographs of polymers in various crystalline aggregates. Indeed, the figures and graphs throughout the book are very carefully thought out and executed. Many of the figures had been presented previously in Dr. Billmeyer's "Textbook of Polymer Chemistry," but in all cases they have been redrawn for greater clarity and effectiveness.

After the discussion of physics, the organic and physical organic chemistry of polymer formation are considered in good detail. The section on radiation chemistry, however, is a little short in view of the importance of the field.

This more "scientific" discussion is followed by two sections on the practical aspects of polymers. First, the properties of commercially available plastics are surveyed. Then their processing as plastics, fibers, and elastomers is discussed. The presentation is well balanced and satisfactory in all respects.

Those familiar with the previous book will be interested in how this one has been changed. It is obvious that the present book is an outgrowth of the previous one. Many of the illustrations have been taken from it and many of the paragraphs have been repeated without too much change. However, it is equally obvious that a great deal of thought has gone into the revision of the material and that many of the specific examples have been brought up-to-date. The organization of the book follows a more logical pattern than the previous one and there have been a number of shifts in emphasis, the most noticeable being the downgrading of fibers and the increased emphasis on polymer processing.

About half of the bibliography listings throughout the book are new. The tables of data have also been extensively revised and brought up to date.



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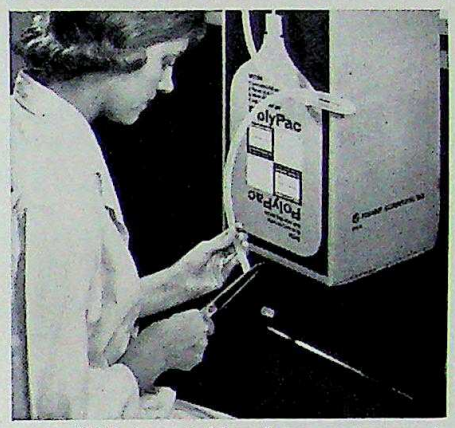

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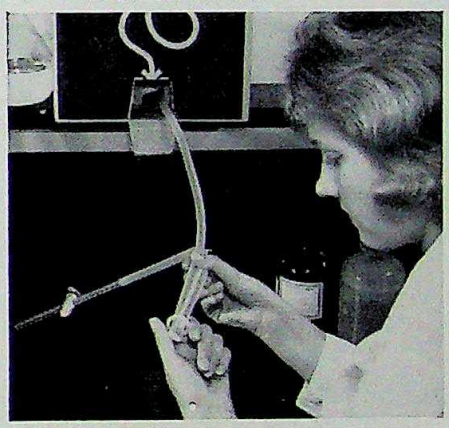

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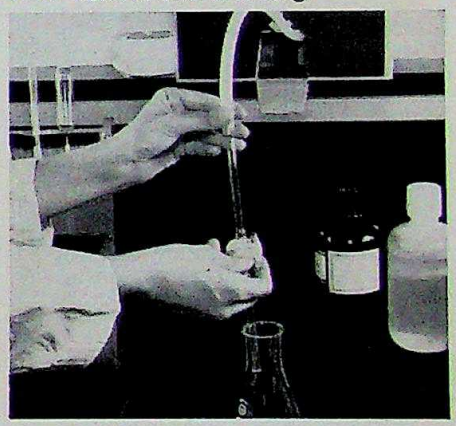

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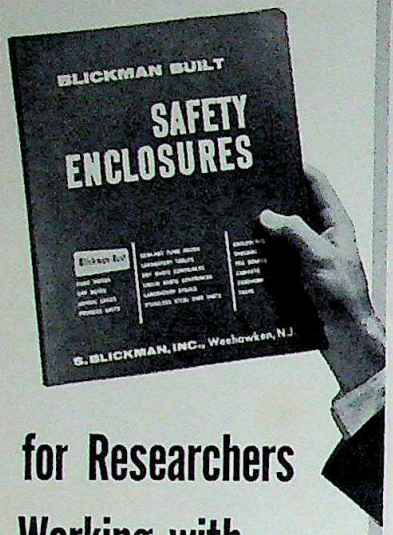

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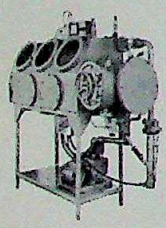

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Because of its outline nature the book is not intended to be the only resource in a polymer course at the senior level. However, when supplemented by additional material in lecture and with use of the extensive references by the students this seems the best general text on polymer science available. It would also be a very useful starting place for one interested in a general survey of the polymer field.

One wonders again, why American scientific books are uniformly so expensive. However, in this case, it is money well spent.

THOMAS E. FERINGTON
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The Enzymes. Volume 6, Group Transfer; Syntheses Coupled to ATP Cleavage

Edited by *Paul D. Boyer*, University of Minnesota, Minneapolis, *Henry Lardy*, University of Wisconsin, Madison, and *Karl Myrback*, University of Stockholm, Sweden. 2nd ed. Academic Press, Inc., New York, 1962. xx + 684 pp. Figs. and tables. 16 × 23.5 cm. $20.

It seems almost unnecessary to bring this sixth volume of a series which began to appear in 1959 to the attention of interested readers. The second edition of "The Enzymes" is indispensable to research workers in enzymology, or any other branch of biochemistry. Unfortunately, such definitive works sometimes make wonderful reference tools but poor reading. The editors and authors are to be commended for their efforts to maintain a generally high level of readability, even in chapters full of facts and data. The present volume covers enzyme catalyzed transfer of phosphoryl, amino, amide and acyl groups, glycosidic bond exchange, acyl group activation and synthesis coupled with ATP cleavage. There are a number of summary chapters, roughly on the topics mentioned above, and about twenty further chapters devoted to specific enzymes or groups of enzymes of these types.

Phosphoryl Group Transfer by R. Nordlie and H. Lardy summarizes with great detail and thoroughness the material presented in about half of the volume. The most chemically oriented chapters are those by W. P. Jencks on acyl group transfer and acyl group activation. They lucidly expound the reactions in question and are spiced with a number of provocative examples from the biochemical literature. Jencks gently, but firmly, re-evaluates the concept of "high energy" bonds in terms of sound physical-chemical principles. The most imposing chapter is ATP-Creatine Transphosphorylase by S. A. Kuby and E. A. Noltmann. It abounds in kinetic expressions and ends in a flourish of computer data neatly photo-offset on six pages. It is instructive to compare the impressive algebra and the detailed calculations with

(*Continued on page A673*)

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the brief and rather vague statements on mechanism of action. The comparison emphasizes the enormous problem involved in attempting to extract meaningful information from a system which contains at least six components.

The general plan of this series has been continued. Each chapter is written by an active research worker in that particular area. The coverage is sometimes more intensive than extensive. This results in a more uniform presentation and avoids a particular review article approach which can result in uncritical presentation of a mass of references. The difference between a discussion which uses references to illustrate a specific point and one which simply abstracts the literature is brought out clearly in a few chapters where some miscellaneous, or recent, data is touched on after the main subject.

This volume of "The Enzymes," like its companions, illustrates the present state of knowledge in this research area. A great deal of information has been obtained about the chemical, physical and biological behavior of enzyme systems. Much of it has been gathered within the last decade, since the first edition was published. In contrast to the older work, the more recent information has been obtained under carefully controlled conditions, to provide quantitative data on kinetics, physical parameters and so forth. Yet, despite this effort, no satisfactory explanation of the specificity and mechanism of action of a single enzyme is available.

George E. Hein
Boston University
Boston, Massachusetts

Physical Techniques in Biological Research. Volume IV, Special Methods

Edited by *William L. Nastuk*, Columbia University, College of Physicians and Surgeons. Academic Press, Inc., New York, 1962. xii + 410 pp. Figs. and tables. 16 × 23.5 cm. $13.

This book, the fourth volume in the "Physical Techniques in Biological Research" series, contains many examples of the highly specialized methodology that is now available to the physiologist, biophysicist, and biochemist. It is difficult for one individual to review adequately areas as diverse as vascular perfusion, flame photometry, and ultrasound. Indeed, it is unlikely that any one investigator will be interested in all the topics discussed. However, the special methods collected in this volume are not minor or peripheral and it is equally unlikely that an investigator in biological research will not find this volume of considerable value.

Chapter 1, Determination of Body Fluid Volumes (Sue Chien and Magnus I. Gregerson), is an outstanding introduction to the subject. Principles and procedures are reviewed with clarity and in detail. Numerous specific methods are described. The discussion of each method

(*Continued on page A674*)

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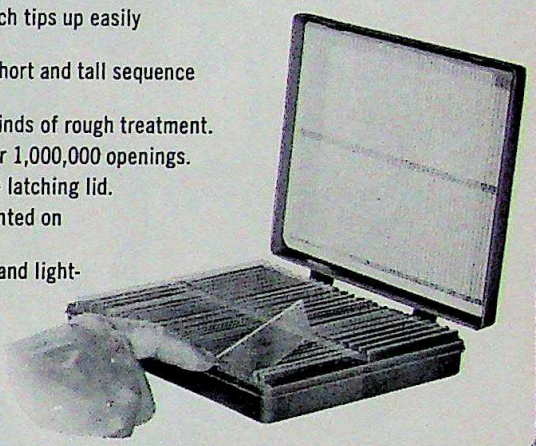

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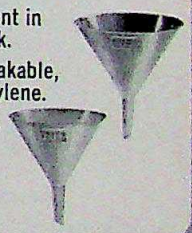

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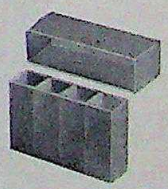

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includes sections on: (1) Chemical and Physical Properties, (2) Procedure, (3) Analytical Methods, (4) Calculation, (5) Validity, (6) Precision, (7) Comments, and (8) Normal Values.

Chapter 2, Techniques of Vascular Perfusion (Eugene M. Renkin), contains a good description of principles and equipment, and an annotated summary of complete perfusion systems. Chapter 3, The Oxygen Cathode (Philip W. Davies), has an interesting historical and theoretical introduction. Electrode characteristics such as residual current and speed of response are discussed in detail. A number of analytical applications are described; however, these two chapters emphasize principles and methodology more than specific applications. This emphasis is important since the literature frequently contains detailed information on a specific application rather than a fundamental discussion of principles.

Chapter 4, Some Physical Techniques Used in the Study of External Respiration (A. B. Otis), includes sections on the description and application of pressure, volume, and flow procedures. A final section describes the methods available for analyzing gases. This section is not an exhaustive discussion; however, references to more detailed discussions are included.

In Chapter 5, Marvin Margoshes has written a good introduction to flame photometry. This chapter includes principles, monochrometers, detectors, applications, internal standards, and recent developments. An excellent discussion of errors is included. This discussion will be of value to the investigator.

The final chapter, Ultrasound: Analysis and Experimental Methods in Biological Research (William J. Fry and Floyd Dunn), contains a detailed theoretical discussion of ultrasound. The section on biological applications is particularly interesting. Many investigators use high acoustic energy levels to disrupt cellular structures. The application of low acoustic energy levels in the visualization of micro and macrostructure is a recent and important area of research.

In the Introduction, the editor suggests that this book was designed to instruct well qualified graduate students and experienced investigators entering a new field. Thus details and comments, the "... invaluable special knowledge that sometimes never finds its way into scientific literature," are included. There is no doubt that the various authors have adhered to this philosophy and produced a volume of real merit and value for the investigator in biological research.

David G. Cornwell
Ohio State University
Columbus

Comprehensive Biochemistry. Volume 1, Atomic and Molecular Structure

Edited by *Marcel Florkin*, University of Liège, Belgium, and *Elmer H. Stotz*, University of Rochester, New York. American Elsevier Publishing Co., New York, 1962. xi + 253 pp. Figs. and tables. 15.5 × 23 cm. $9.50 (if purchasing series); $11.50 (single copy).

Volume 3, Methods for the Study of Molecules

XIII + 324 pp. $11.50 (series); $14.50 (single copy).

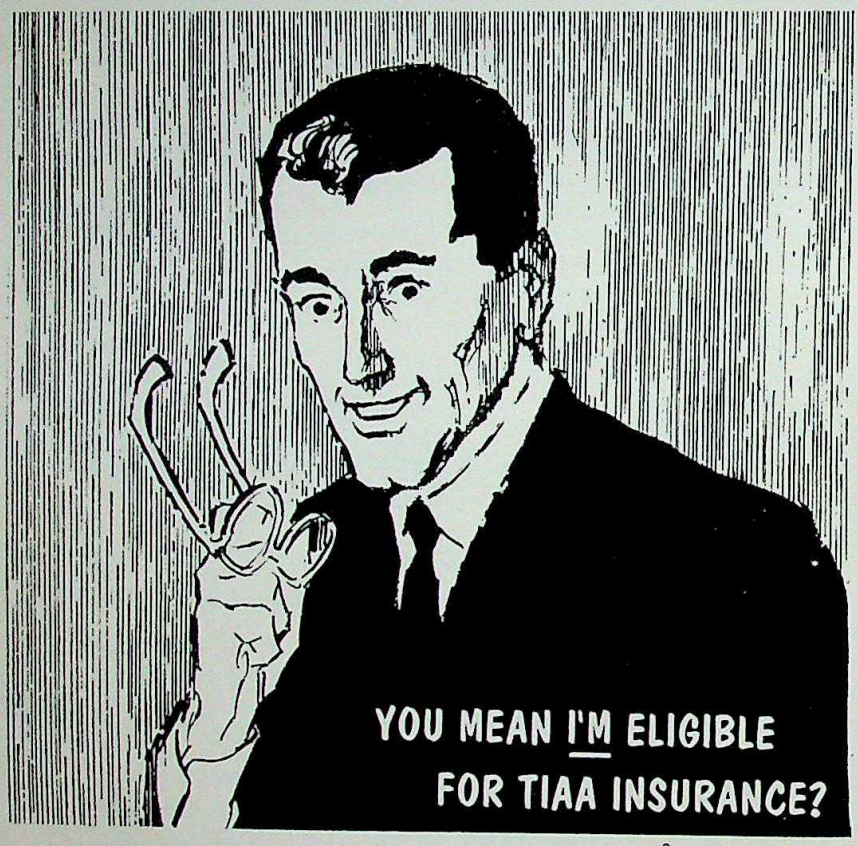
Volume 4, Separation Methods

XIII + 282 pp. $10.50 (series); $13. (single copy).

The over-all organization of "Comprehensive Biochemistry" entails five major sections: Physico-Chemical and Organic Aspects of Biochemistry, Chemistry of Biological Compounds, Biochemical Reaction Mechanisms, Metabolism, and Chemical Biology. Volume 4, reviewed here with Volumes 1 and 3 (see J. CHEM. ED., 40, A226 [1963] for a review of Volume 2), completes the first section of this advanced treatise.

Volume 1 contains four chapters devoted to structure, beginning with an excellent review of atomic structure and of the electronic theory of organic molecules. The third chapter, by J. D. Bernal, treating the physical and chemical aspects of the structure of the major classes of biochemical molecules, is exceptional not only because of its extensive bibliography, but also with regard to well-chosen diagrams and electron-microscope photographs. The final chapter of Volume

(*Continued on page A675*)



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1 treats stereoisomerism and has a particularly lucid discussion of the determination of configuration.

Volumes 3 and 4 are concerned with methodology. The first two chapters of Volume 3 review the principles and applications of crystallography and X-ray diffraction in biochemistry. The following four chapters are concerned with all aspects of spectroscopy, including analyses by emission spectroscopy, ultraviolet, visible and infra-red spectrophotometry, and fluorescence. R. A. Morton's chapter on spectrophotometry in the UV and visible regions, which includes a wealth of spectroscopic data on all of the major biological compounds, will be welcome to everyone employing this technique. Following these chapters on conventional spectrophotometry are two on the newer techniques of electron paramagnetic resonance (by S. I. Weissman) and nuclear magnetic resonance (by C. D. and O. Jardetsky). Both chapters present excellent illustrations of the application of these techniques to biochemistry. Volume 3 is completed with a critical review of the determination of mass, form, and dimensions of large particles in solution, dealing with the problems of rigid particles, flexible chains, and polydispersity.

Volume 4 of Comprehensive Biochemistry is devoted entirely to separation methods and its three chapters treat counter current distribution, chromatography, and gas chromatography. In the reviewer's opinion, this volume contains the best critiques of these techniques in the current literature.

Certainly the topics treated in the first four volumes of Comprehensive Biochemistry underscore the extent to which the modern biochemist and biologist must depend on recent advances in physical and organic chemistry. Taken as a totality, the topics chosen for review in Section I have accomplished their central purpose of helping the advanced student and investigator appreciate more keenly the origins and future directions of biological chemistry.

W. R. Frisell
University of Colorado School of Medicine
Denver

Russian-English Chemical Reader: Russko-Angliiskaya Kniga dlya Chteniya po Khimii.

Alex A. Kramer. D. Van Nostrand Co., Inc., Princeton, New Jersey, 1963. vii + 311 pp. 16 × 23.5 cm. $7.50.

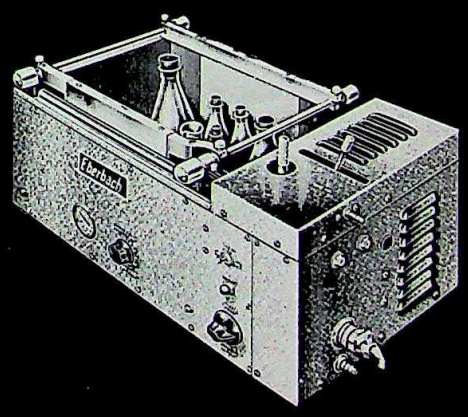
Using the effective device of text on one page and its translation on the opposite page, Engineer Kramer presents his own Russian text and his own rendition thereof in English. Using the type faces (including Cyrillic characters) and typographical devices acquired by extensive and intensive experience in chemical publishing, the printer and publisher have neatly turned the trick of bilingual facing pages while giving a deceptive appearance of effortless ease. This takes prestidigitation, though none is apparent to readers interested only in the languages.

The range of chemical subject matter has a something-for-everybody aspect in a logically simple arrangement of 4 parts: Theory and Basic Laws, Inorganic Chemistry, Organic Chemistry, Nuclear Reactions. Part I proceeds from atomic-molecular theory to the principal laws and their modes of expression (symbols, formulas, equations). Part II passes from H_2, O_2, and their compounds through a succession of element groups to the last and longest chapter, the metals. Students more interested in theory than in practical applications will find ample material on which to cut their linguistic teeth. Those more interested in applied chemistry will also find rewarding quantities of text, not in process details but with an extensive vocabulary from the process industries.

Part III, Organic Chemistry, follows a similar plan by types of compounds rather than by elements, but again with theory and practical aspects duly covered under each. Where this approach does not serve so well an industry base is employed with equally good effect, particularly for petroleum refining and coke chemicals.

Part IV, Nuclear Reactions, is a topic which lends itself well to a more intimate blending of theory and practice. Readers seeking either emphasis will need the vocabulary of both and will find they need to study the full text with care to

(*Continued on page A676*)



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improve their fluency in Russian in this new and relatively difficult field.

The text flows smoothly and easily in both languages, making it difficult to tell which is the author's native tongue. There are occasions in which the English lacks polish, but Engineer Kramer (whether wittingly or not) has written his own defense in the preface, where he says the translation to English is as literal as possible. For this instructional purpose the eternal battle between elegance and faithfully exact rendition of the original meaning often demands some sacrifice of elegance. The battle has been waged exceptionally well here; while not a word is said about the principles of technical translation, astute students who can read between the lines can find much guidance along this line.

The Russian-English chemical glossary shows a slight leaning toward British rather than American spelling, but redeems itself by uniformly using *sulf-* instead of *sulph-*. It is a helpful aid to readers, but there is no intention to relieve them of any need for a dictionary while reading the Russian text in comparison with the English. The bilingual table of atomic weights (though not on the new base of $^{12}C = 12$) is also helpful since some of the rarer elements are not mentioned in the text.

Both author and publisher (ably aided by the printer) are to be commended for a difficult task well performed.

JULIAN F. SMITH
Lenior Rhyne College
Hickory, North Carolina

German-English Chemical Terminology: Englische und deutsche chemische Fachausdrücke

Alexander King, Organization for Economic Cooperation and Development, Paris, France, and *Hans Fromherz*, Schwyz, Switzerland. 4th ed. Verlag Chemie, Weinheim/Bergstrasse, 1963. xxi + 588 pp. 16 × 22 cm. $12.

For nearly three decades the Fromherz plan of teaching chemical terminology both by example (context) and by precept (definitions) has been helping chemists across the language barrier in both directions. With German and English text on facing pages for context and with an alphabetized glossary for each language, readers can readily see how the glossary meaning fits into different contexts. Following *Chemical Abstracts*, pages are divided into ninths vertically, and page references in the glossaries are by number and letter to facilitate locating terms.

Each technical term is italicized the first time it appears, so that repetitions are readily recognized as such. As would be expected with Dr. King as coauthor, British spelling is used in the English text; but at the first occurrence of *sulph-* the American *sulf-* is given due recognition. As might also be expected from the cumulative writing skill of the Fromherz-King axis, neither text shows any conspicuous evidence (beyond conveying the same information) that it is a translation of the other.

Rather than attempt to introduce the vocabularies of the chemical process industries, the main emphasis throughout is on chemistry as such, with frequent mention of practical applications but without details. The five parts reflect this emphasis: Elementary, Inorganic, Organic and Physical Chemistry, and Structure of Matter. Useful supplementary information appears in Appendix I, Atomic Weights; II, Mathematical terms; III, Abbreviations (English and German). As a special aid to German readers, there is a short guide to pronunciation of English technical terms. Finally there are the two glossaries (English and German). Growth from Edition 1 (1934) to Edition 4 (1963) has expanded these glossaries from about 4000 to more than 10,000 terms.

Passages are taken from many sources and are not identified by direct literature citations, but a list of principal sources is included as a bibliography. The book is well made; though the type is rather small, it is clear and easy to read. The type is such as to permit effective use of white space without making the volume overly bulky. Beginners in chemical German can use this dual text to excellent advan-

(*Continued on page A677*)

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tage, aided by a general dictionary; readers with greater fluency can find much help in clarifying finer shades of meaning, such as cannot be indicated by dictionary definitions.

JULIAN F. SMITH
Lenoir Rhyne College
Hickory, North Carolina

Encyclopedia of Chemical Technology. Volume 1, A to Aluminum

Anthony Standen executive editor. Interscience Publishers (a division of John Wiley and Sons, Inc.), New York, 1963. xix + 990 pp. 19 × 27 cm. Figs. and tables. $35. (subscription); $45. (single copy).

This is a second edition of a well-known and much used reference work. The various volumes of the first edition were published in alphabetical order over the years 1947 to 1956. Thus, the material covered in the present volume in the first edition is 16 years old. Because of the tremendous scientific and engineering advances made during those years, most of the topics have been completely rewritten, in some cases by the same author as in the first edition, in some cases by a different author. Therefore, the editors' statement that this is essentially a new encyclopedia is justified. Most of the topics covered are the same as in the first edition, although quite a few new technological subjects, such as ablation, have been added. The balance between theoretical and applied treatments for various topics is retained.

Each of the authors is an authority in his field. One change from the first edition, however, is that many of the new authors are not American, thus providing an international coverage. This is a welcome modification since much important technological work has been done throughout the world in countries other than the U.S.A. in recent years, which must be discussed to have a reasonably complete treatment of chemical technology.

In summary, this encyclopedia is an excellent source of information on a great number of topics. It will be a necessary part of any chemistry or chemical engineering library.

KENNETH B. BISCHOFF
University of Texas
Austin

Ion Flotation

Felix Sebba, University of the Witwatersrand, Johannesburg, South Africa. American Elsevier Publishing Co., New York, 1963. 154 pp. Figures. 13.5× 19.5 cm. $5.50.

The title "Ion Flotation" was sufficiently mystifying to stimulate a wish to review this monograph. Unquestionably, Dr. Sebba deserves credit for focusing attention on the potential fundamental and practical utility of well-known interfacial phenomena in liquid-liquid (and solid-liquid) interfaces in a broad manner.

Except for Chapter 1, the Introduction and the next four chapters treat fundamentals. The discussions of surface activity, micelles, foams and froths, and ions in solution are far from comprehensive. This is not surprising in this short monograph. These chapters are necessary, however, because the book was written for both specialists and non-specialists. Besides their merit as foundation material, there are bits of information in each chapter which either are new or have been forgotten, even by the specialist. The chapter on ions in solution was particularly interesting.

The following list of applications for flotation is given: Concentration and/or separation of ionic species in industry. Preparation of new compounds. A tool for academic (and practical) studies of the behavior and properties of ions in solution. An analytical technique.

Concentration of molecules from solution obviously is the result of their tendency to collect at interfaces. The author suggests the use of air bubbles, for example, as a means to achieve a desired extension of the interface. Micelle formation reduces or eliminates the tendency of a surfactant to concentrate at an interface, and methods are discussed to overcome this undesirable state. Indeed, much of

(*Continued on page A678*)

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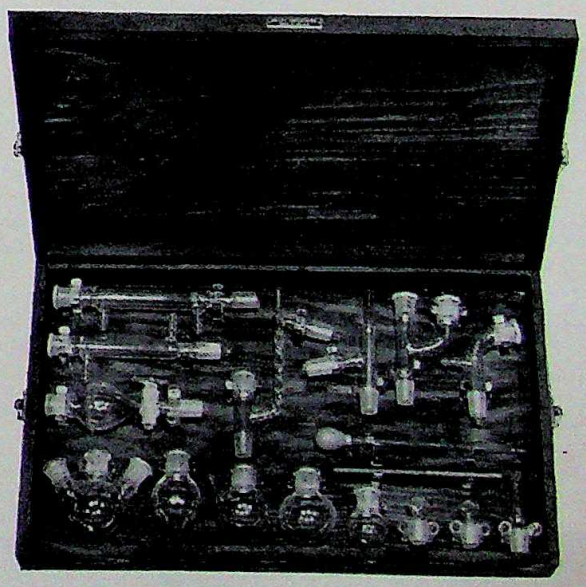

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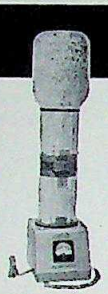

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the value of this monograph lies in the details of suitable apparatus and techniques of procedure which it contains. For example, analytical methods applicable to inorganic ions of each periodic table subgroup were devised by the author. Important variables such as collector type, pH and temperature, are considered also.

The value of this monograph is principally the emphasis placed on the broad potential utility of the technique of ion flotation. It will suffice if efforts of other scientists are stimulated to increase the list of applications. Perhaps most industrial and institutional libraries will add this volume automatically to their collections; however, there is little need for the individual scientist to do so.

JOHN CHESSICK
Lehigh University
Bethlehem, Pennsylvania

Multicomponent Distillation

Charles D. Holland, Agricultural and Mechanical College of Texas, College Station. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1963. xiii + 506 pp. Figs. and tables. 16 × 23.5 cm. $11.25.

The application of high speed computers for making muticomponent distillation calculations is the primary concern of the author. This is the first book to present several numerical methods for obtaining steady state solutions of multicomponent distillation problems. Most of the emphasis is placed on the "convergence method" and on the various equations that describe the operation of various distillation units rather than on general ideas and philosophies, such as the selection of a particular type of distillation to be employed for a given separation.

In a very clear and concise presentation the author presents one general calculational procedure for obtaining exact computer solutions to problems associated with distillation units. The book covers adequately multiple feed plates, side streams, absorbers, strippers, reboiler-absorbers, and systems of columns with recycle.

The book contains many innovations, including: proof of the existence of a zone of constant composition, new procedures of minimization of round-off errors, new methods of making enthalpy balances, new method of obtaining plate efficiencies from operational data.

In addition the author presents a very understandable treatment of the fundamental principles of the thermodynamics of vapor-liquid equilibria for multicomponent mixtures. He includes a very good treatment of the principles of new methods for the correlation of K-values, activity coefficients and ethalpies.

The titles of the chapters will indicate the thoroughness of the subject. These are: Fundamental Concepts Involved in Multicomponent Distillation Calculations (13 pages); Calculational Procedures for

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BOOK REVIEWS

Bubble Point and Dew Point Temperatures and Flash Distillations (18 pages); Solution of the Material Balance and Equilibrium Relations for Conventional Distillation Columns (24 pages); Convergence Methods (32 pages); Enthalpy Balances for Conventional Columns (16 pages); Further Refinements for Conventional Columns (19 pages); Complex Columns (22 pages); Absorbers and Strippers (16 pages); Conventional and Complex Columns at Total Reflux, Total Reboil, and Total Recycle (6 pages); Conventional and Complex Columns at Minimum Reflux (33 pages); Determination of the Minimum Reflux for Conventional and Complex Columns (7 pages); Treatment of Distillation Columns with Side Strippers (9 pages); θ-method of Conversion for Systems of Distillation Columns (20 pages); The Use of Efficiencies for Mass and Heat Transfer in Conventional and Complex Columns (11 pages); Determination of Plate Efficiencies (11 pages); Thermodynamics of Vapor-Liquid Equilibrium of Multicomponent Mixtures (25 pages); Correlation of Vapor-Liquid Equilibria for Multicomponent Mixtures (47 pages).

This book should be in the library of everyone interested in the subject.

JOHN J. MCKETTA
University of Texas
Austin

Treatise on Analytical Chemistry. Part II, Analytical Chemistry of the Elements. Volume 2 and Volume 9

Edited by *I. M. Kolthoff*, University of Minnesota, Minneapolis, and *Philip J. Elving*, University of Michigan, Ann Arbor, with the assistance of *Ernest B. Sandell*, University of Minnesota. Interscience Publishers (a division of John Wiley and Sons), New York, 1962. Volume 2, xx + 471 pp. Volume 9, xvi + 491 pp. Figs. and tables. 17 × 24 cm. $18 each.

(For reviews of previous volumes of this treatise see THIS JOURNAL **37**, 108 [1960], **38**, A842, A844 [1961], **39**, A52, A132, A604, A913 [1962]. These, the fifth and sixth volumes of Part II to appear, continue the systematic treatment of the analytical chemistry of the various elements, and bring the number of elements considered to 54, so that approximately half of the elements have now been covered. The organization of each chapter follows the outline previously described.

Volume 2 begins with a 104 page chapter on Gallium, Indium and Thallium by Hiroshi Onishi. The analytical chemistry of Silicon is considered in the 99 page chapter written by H. R. Shell, while John R. Musgrove authored the 38 pages devoted to Germanium. A chapter of 63 pages by L. M. Melnick develops the analytical chemistry of Iron. The final two chapters are both written by John M. Dale and Charles V. Banks and cover Cobalt in 65 pages and Nickel in 63 pages.

While it is perhaps inevitable in the preparation of a treatise of this magnitude, one cannot help feeling a bit disappointed at the relative paucity of more recent literature citations, for very few references later than 1959 appear. A few omissions are noted. Thus, no reference to the ion exchange separation of Germanium developed by Klement and Sandmann and by Cabbell, *et al.*, are noted. References to the work of Bode in the solvent extraction of various metal diethyl dithio carbamates seem to have escaped detection.

Volume 9 is devoted entirely to the analytical chemistry of Uranium and the Actinides. The very comprehensive section on Uranium was written by Glenn L. Booman and James E. Rein and occupies 188 pages with over 900 references cited. The Transuranium Actinide elements are thoroughly covered in the 251 page chapter, with nearly 400 references, authored by Charles F. Metz and Glenn R. Waterbury. This chapter is wisely divided into two major sections, one covering Neptunium, Plutonium and Americium, and the second devoted to Curium through Lawrencium. Quite naturally, the latter section is brief. Description of procedures in this volume is unusually complete, and the rich experience of the authors is very evident. Certainly this volume is most timely as it represents the

(*Continued on page A681*)

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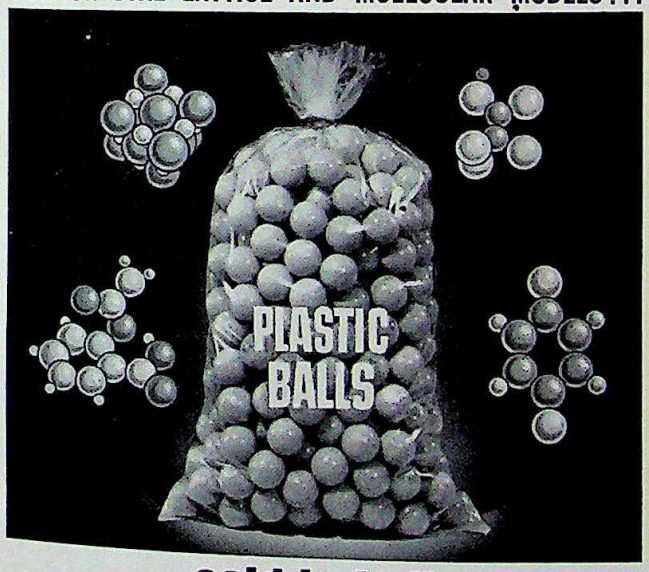

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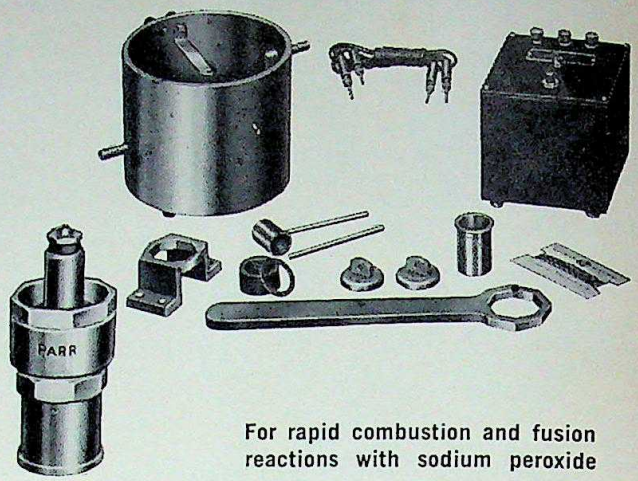

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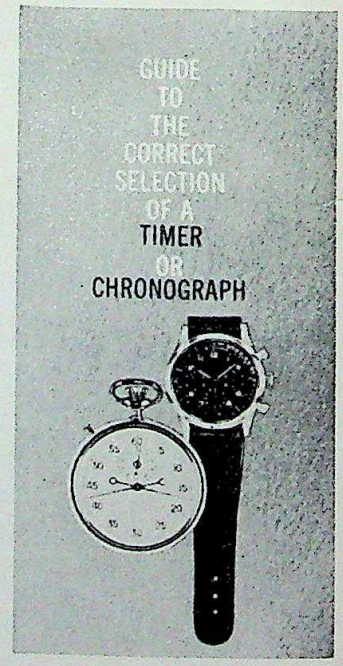

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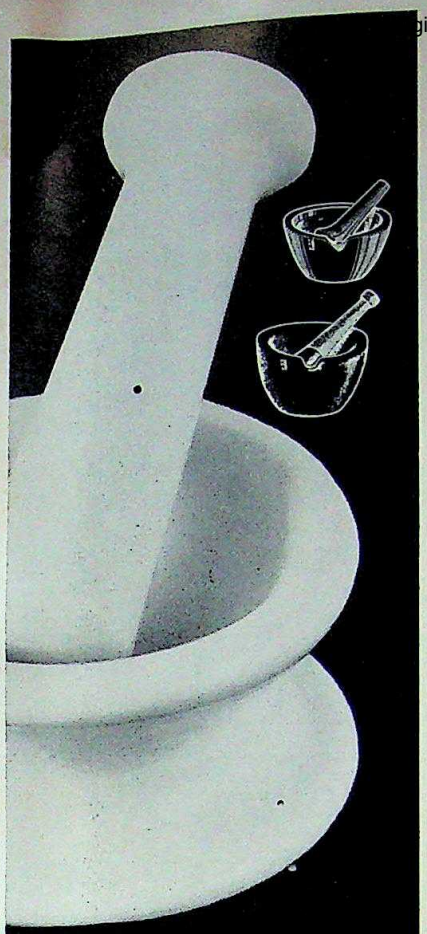

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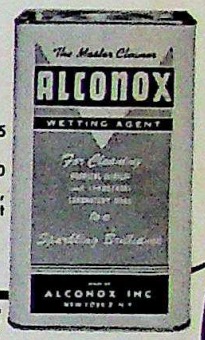

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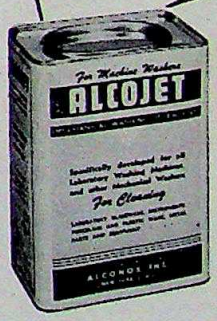

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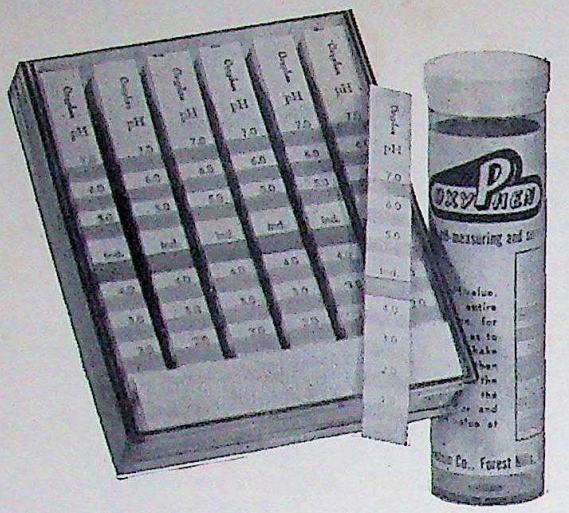

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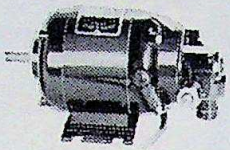

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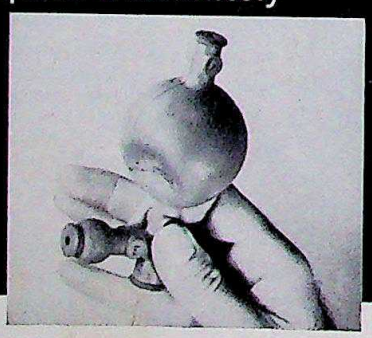

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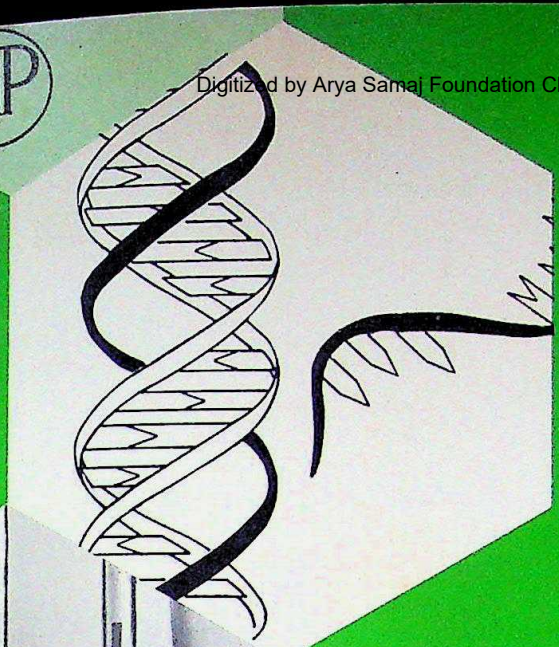

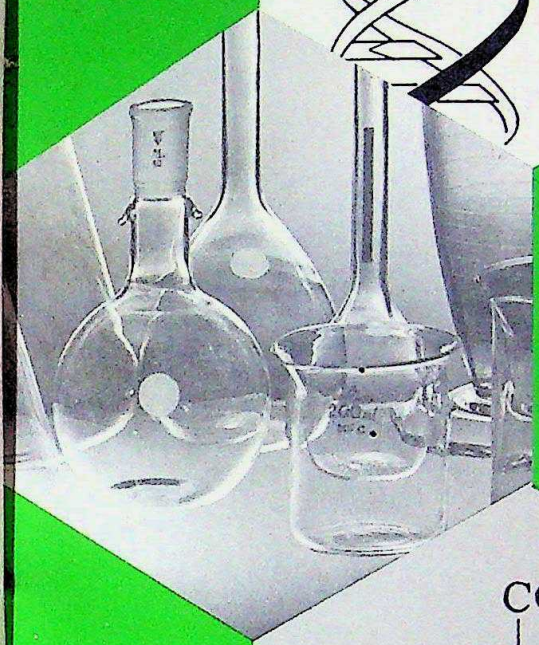

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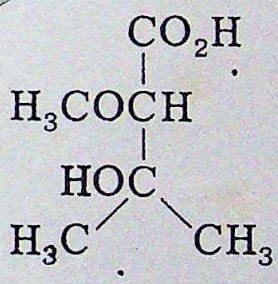

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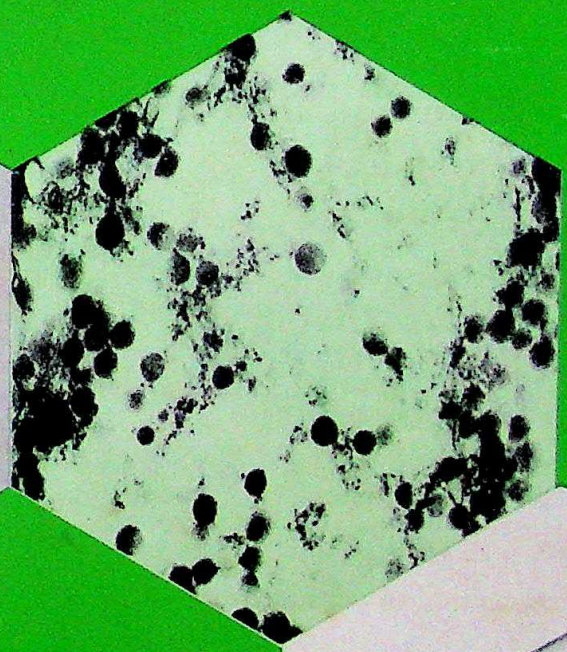

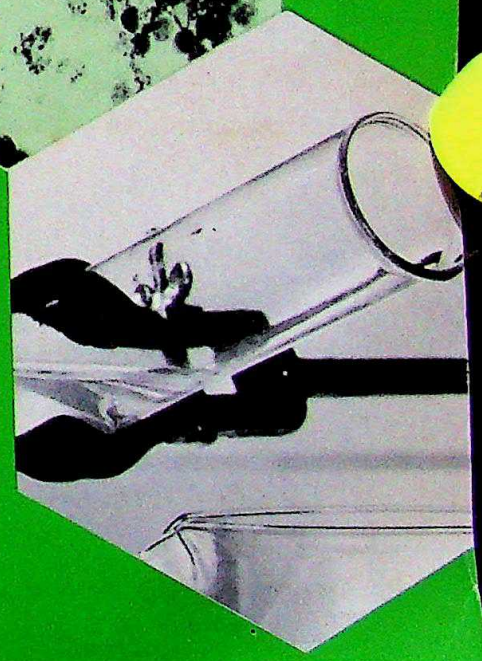

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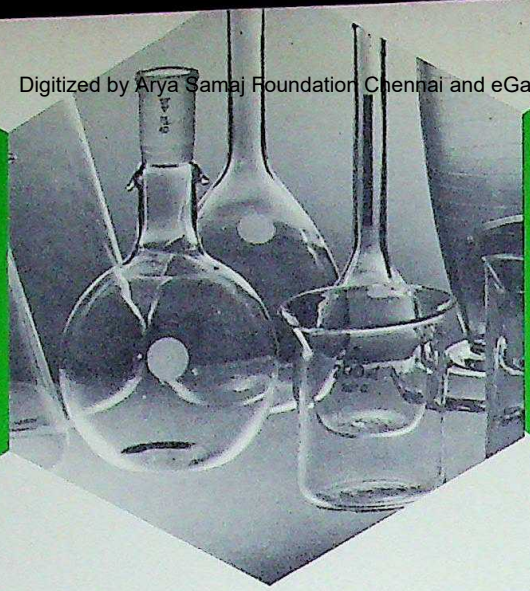

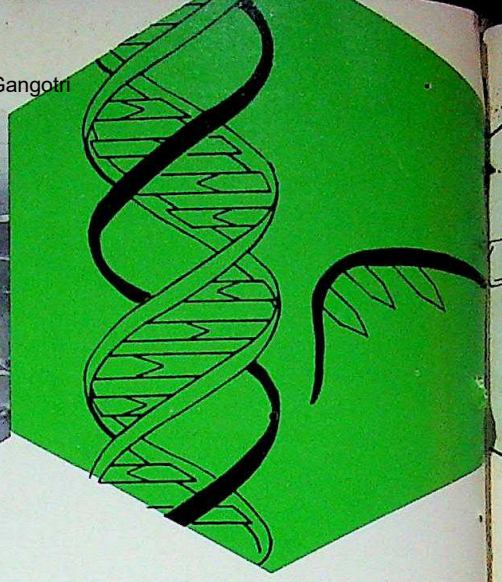

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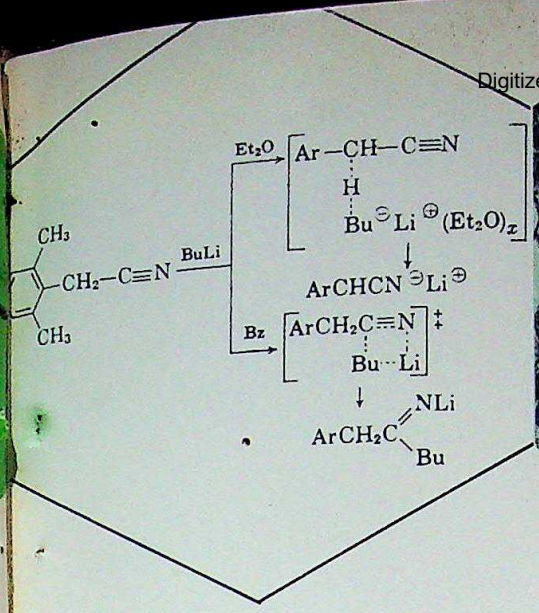

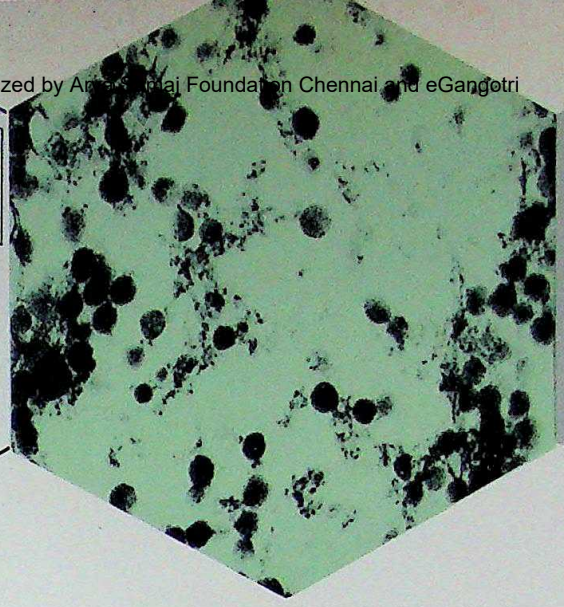

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Volume 1, 1963, about 450 pp.

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Volume 1, Fall 1963 about 300 pp.

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Volume 1, Late 1963, about 300 pp.

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Edited by V. Gold
Volume 1, April 1963, 443 pp., $13.00

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Volume 1, June 1963, 350 pp., $13.00

Progress in Chemical Toxicology
Edited by Abraham Stolman
Volume 1, Fall 1963, about 375 pp.

Progress in Dielectrics
Edited by J. B. Birks
Volume 4, 1962, 310 pp., $12.00

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Edited by J. N. Davidson and W. E. Cohn
Volume 1, May 1963, 424 pp., $13.00

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The Proceedings of the Laurentian Hormone Conference
Edited by Gregory Pincus
Volume 19, Summer 1963, about 750 pp.

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Edited by Francis A. Gunther
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Edited by Frederick Seitz and and David Turnbull
Volume 15, Fall 1963, about 400 pp.

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Edited by David Seligson
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Edited by Arthur F. Scott
Volume 1, Fall 1963, about 325 pp.

Vitamins and Hormones
Edited by Robert S. Harris, J. A. Loraine, and I. G. Wool
Volume 21, Late 1963, about 225 pp.

PAPERBACKS

Division of Labor in Cells
By G. H. Bourne
1962, 248 pp., $2.95

Design and Function at the Threshold of Life: The Viruses
By H. Fraenkel-Conrat
1962, 117 pp., plus 19 photographic plates, $1.95

Time, Cells, and Aging
By B. L. Strehler
1962, 270 pp., $2.95
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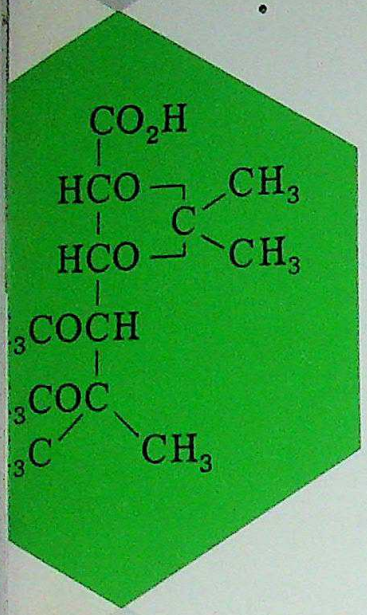

Introduction to Modern Biochemistry

By **P. KARLSON,** *Institute of Physiological Chemistry, University of Munich, Germany*

Translated from the German by Charles H. Doering
With a Foreword by Adolf Butenandt

May 1963, 434 pp., $10.00

The work synthesizes the vast knowledge gained in recent years in such fields of research as molecular biology; the chemistry of vitamins and hormones; the constitution and mechanism of action of enzymes; metabolism; and the production, conversion, and utilization of energy. The information is presented in a clear and concise manner, and the most modern viewpoint is employed wherever sufficient evidence substantiates it.

The examples and illustrations are particularly suited for teaching purposes, and the inclusion of a large folding chart of metabolic pathways will also help make this work an invaluable teaching guide.

Enzymes

Second Edition

By **MALCOLM DIXON** and **EDWIN C. WEBB,** *Cambridge University, England*

Late fall 1963, about 825 pp.

In the five years since the first edition of this book was written, a good deal has happened in the field of enzymology. Over 170 new enzymes have been recognized, and there have been considerable advances in many parts of the subject in other ways.

The general form of the first edition has been retained, with some rearrangement, but the material has been completely revised and many parts have been rewritten. A great deal of new material has been incorporated, notably a section on general enzyme kinetics; a chapter on enzyme classification; new sections on enzyme mechanisms; a long section on the mechanism of the biosynthesis of enzymes, its genetic control and regulation by induction, feedback inhibition and repression; and expanded tables of metabolic enzyme systems.

The Chemistry and Function of Proteins

(Second Edition of Chemistry and Biology of Proteins)

By **FELIX HAUROWITZ,** *Distinguished Service Professor of Chemistry Indiana University, Bloomington, Indiana*

July 1963, 455 pp., $10.00

Reflecting the enormous advances made in the study of protein structure and function, this work is a ninety percent revision of Professor Haurowitz's earlier work, *Chemistry and Biology of Proteins.* The text is presented in two sections.

Section I is a clear and concise description of the isolation of proteins, their purification, methods for their partial hydrolysis, and methods for the determination of the amino acid sequence.

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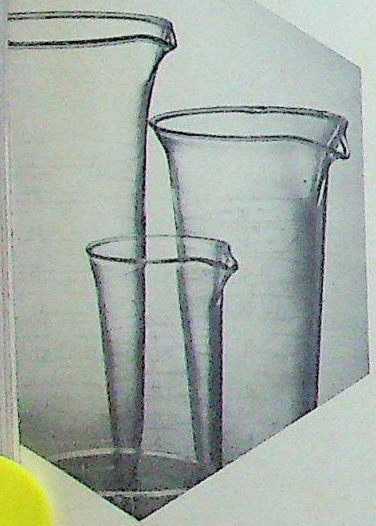

Study Projects in Physical Chemistry

By **F. E. CONDON,** *Professor of Chemistry, The City College of New York*

June 1963, 203 pp. (plus 32 sheets of graph paper), $4.75

This is a unique collection of twenty-four study projects, *not a problem book or laboratory manual,* which utilize the material of junior and senior one-year survey courses in physical chemistry. Each project consists of a clear statement of objectives; experimental data carefully selected from the original literature; a brief discussion of pertinent theory in which equations are presented and their terms defined; and detailed instructions for the treatment of the material. The student is given data and guided in its application through extensive calculations to the solution of specific problems or the determination of constants.

Energy

By **BRUCE CHALMERS,** *Gordon McKay Professor of Metallurgy Division of Engineering and Applied Physics Harvard University, Cambridge, Massachusetts*

April 1963, 289 pp., $5.75

Designed specifically as an undergraduate text for introductory courses in the physical sciences, Dr. Chalmers' book is the first to treat the subject of energy in all of its aspects. It describes, in clear and concise language, the many forms in which energy can exist, covering all aspects of storage, transmission, and exploitation. The text also covers the conversion of energy from one form to another, and the part which energy plays in modern technology. The treatment, although quantitative, involves a minimum of mathematics. The possibilities and limitations inherent in future developments are discussed in relation to each form of energy.

Laboratory Studies in General Chemistry

By **FRANK BRESCIA, HERBERT MEISLICH, AMOS TURK, JOHN ARENTS,** and **ADOLPH ANDERSON,** *The City College of New York*

With an instructor's manual

1960, 210 pp., $3.25

Experiments in *Laboratory Studies in General Chemistry* have been selected and designed for the education and stimulation of the student to increase his interest and independent thought. The fifty-four experiments included have been used in teaching several thousand students with a background of high school chemistry. The results of this approach have shown the advantage of assuring that the student cannot proceed without understanding the meaning of his work in relation to what he has learned from the lectures and his textbook.

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Burnip, H. *Mathematics Revision Handbook.* 84 pp $1.75 Butterworth, Inc. #4

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Chemical Education Material Study. *Chemistry-An Experimental Science.* 1963 466 pp $5.80 Chemical Education Material Study. #6

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Survey (Physical Sciences)

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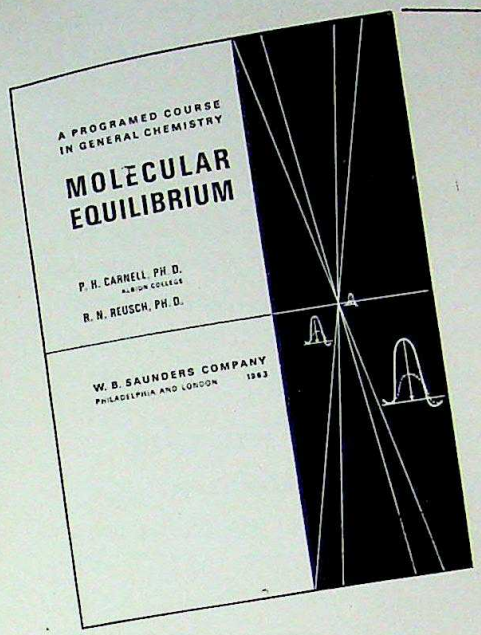

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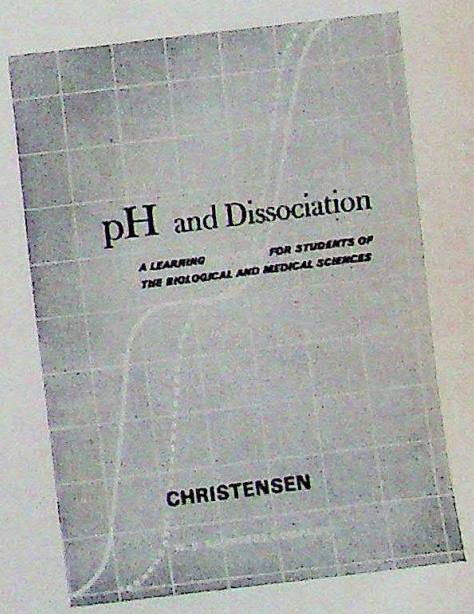

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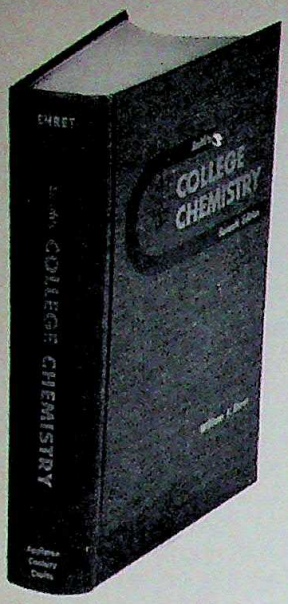

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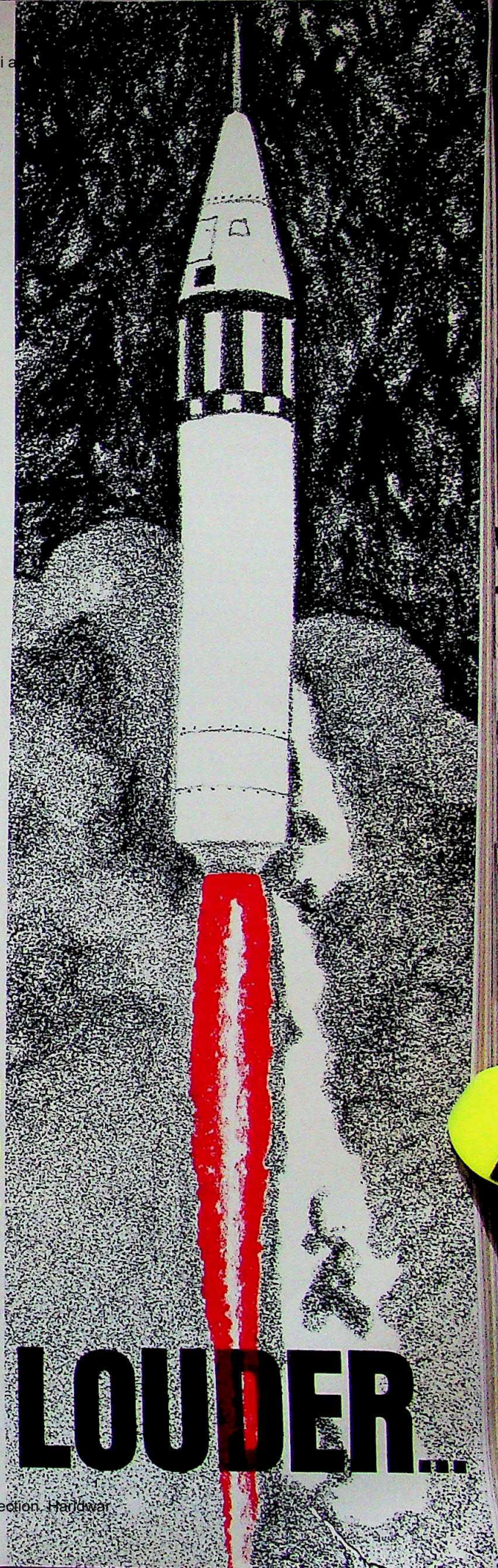

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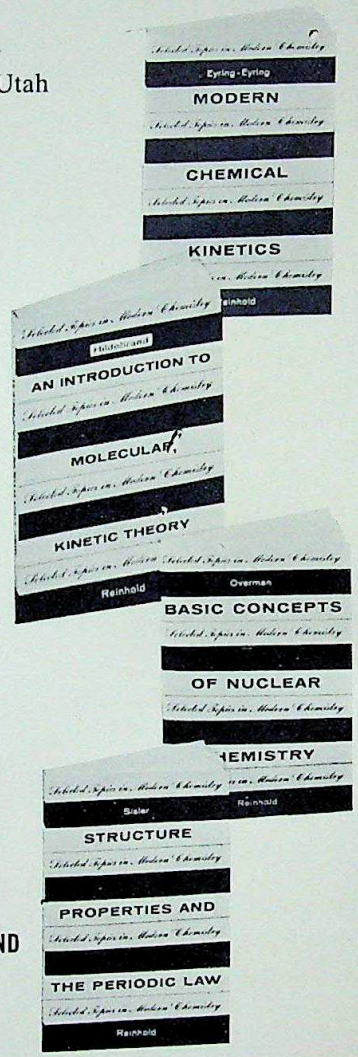

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Wilson, C. L. and **Wilson, D. W.** *Comprehensive Analytical Chemistry.* Volume I-C 1962 758 pp $24.00 American Elsevier Publishing Co., Inc. #358

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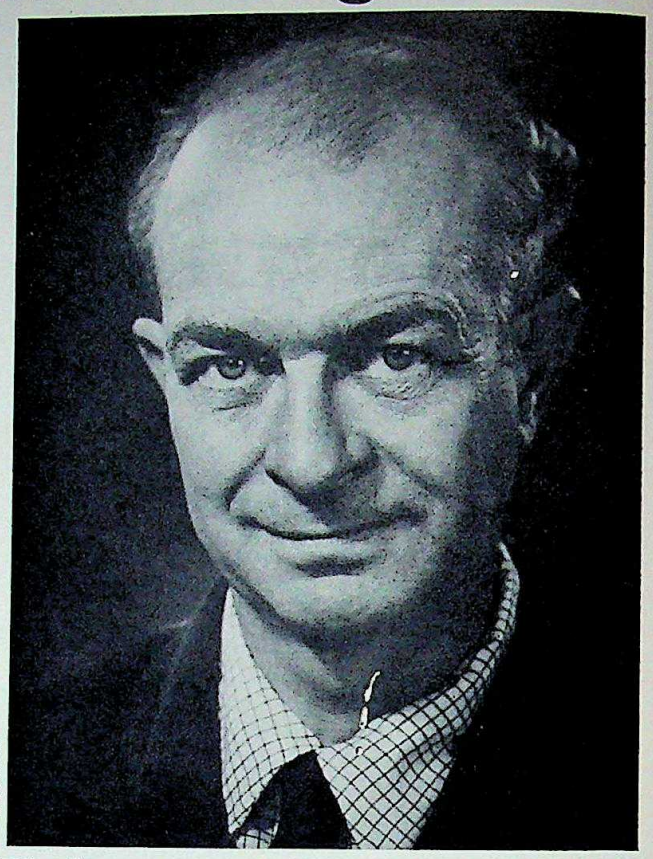

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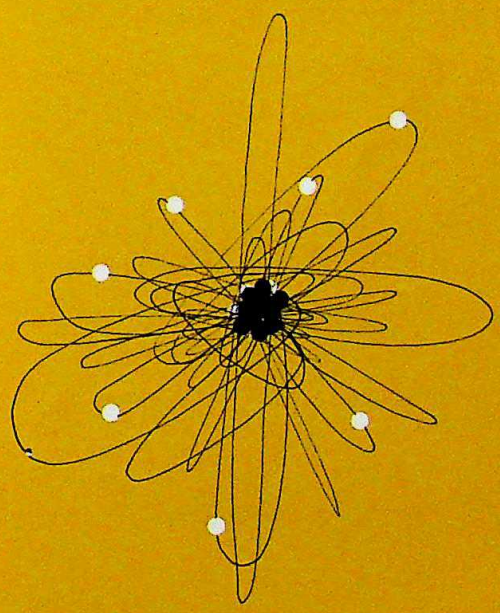

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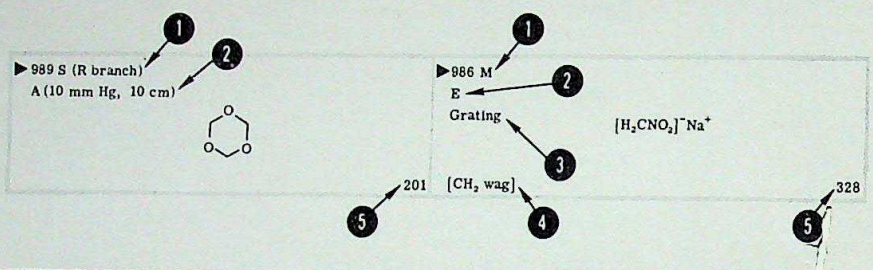

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Gould. *Inorganic Relations and Structure.* Revised Edition 1962 500 pp $8.50 Holt, Rinehart & Winston, Inc. #781

Harvey, K. B. and **Porter, G. B.** *An Introduction to Physical Inorganic Chemistry.* 1963 512 pp Probably $9.75 Addison Wesley Publishing Co. #782

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Jolly, William L. *Synthetic Inorganic Chemistry.* 1960 196 pp $6.95 Prentice-Hall, Inc. #784

Kleinberg, J.; Argersinger, W. J. and **Griswold, E.** *Inorganic Chemistry.* 1960 688 pp $11.50 D. C. Heath & Co. #785

Lappert, M. F. *Developments in Inorganic Polymer Chemistry.* 1962 300 pp $10.00 American Elsevier Publishing Co., Inc. #786

Latimer, W. and **Hildebrand, J.** *Reference Book of Inorganic Chemistry.* 3rd Edition 1951 625 pp $6.95 The Macmillan Co. #787

Lipscomb, William N. *Boron Hydrides.* 1963 350 pp $10.00 W. A. Benjamin, Inc. #788

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Sienko, Mitchell J. and **Plane, Robert A.** *Physical Inorganic Chemistry.* 1963 200 pp $3.95 Paperbound $7.00 Clothbound W. A. Benjamin, Inc. #790

Schlessinger, Gert G. *Inorganic Laboratory Preparations.* 1962 294 pp $12.00 Chemical Publishing Co. #791

Tyreee, S. Y. and **Knox, K.** *Textbook of Inorganic Chemistry.* 1961 434 pp $7.50 The Macmillan Co. #792

Van Nieuwenburg, C. J. *Quantitative Chemical Micro Analysis.* 1963 200 pp $6.00 American Elsevier Publishing Co., Inc. #793

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The American Ceramic Society. *Advances in Glass Technology.* Part I—Technical Papers 1962 661 pp $21.00 Plenum Press. #796

Audrieth, L. V. *Inorganic Syntheses.* Volume III 1950 230 pp $7.50 McGraw-Hill Book Co. #797

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Malmstadt, Howard V., Enke, Christie G. and Toren, E. Clifford. *Electronics for Scientists.* 1962 632 pp $10.75 W. A. Benjamin, Inc. #855

Matson, Frederick R. and Rindone, Editors. *Advances in Glass Technology.* Part II—Technical Papers, Brief Communications, Historical and General Papers Compiled by the American Ceramic Society 1963 In press Plenum Press. #856

Mazelev, L. Ya. *Borate Glasses.* 1960 165 pp $12.50 Consultants Bureau Enterprises. #857

Mellor, J. W. *A Comprehensive Treatise on Inorganic and Theoretical Chemistry.* Volume II (Supplement I: The Halogens) 1956 1153 pp $37.50 John Wiley & Sons #858

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Wells, A. F. *Structural Inorganic Chemistry.* 3rd Edition 1962 1055 pp $17.00 Oxford University Press. #909

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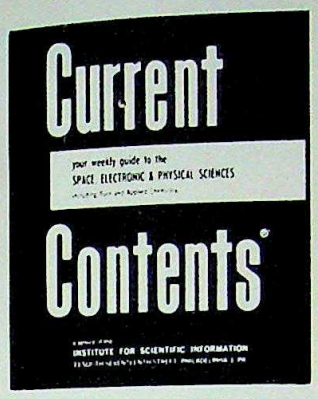

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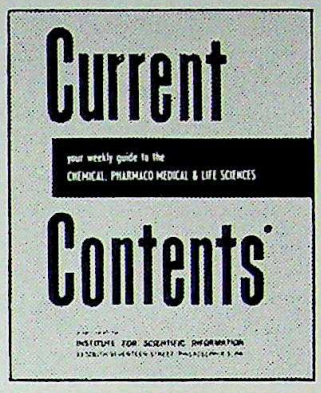

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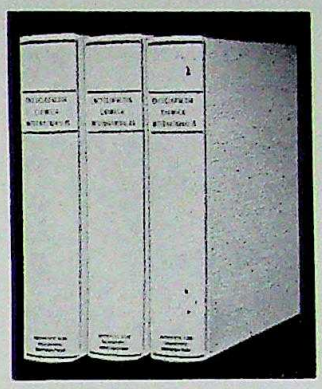

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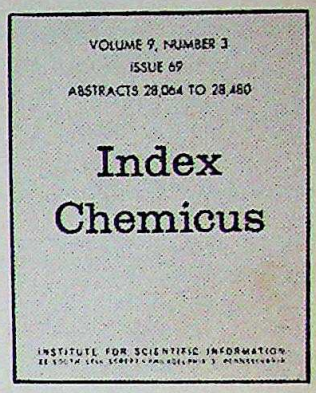

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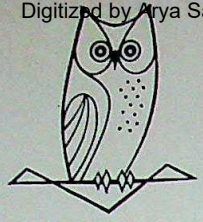

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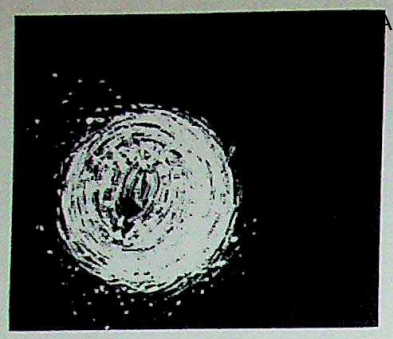

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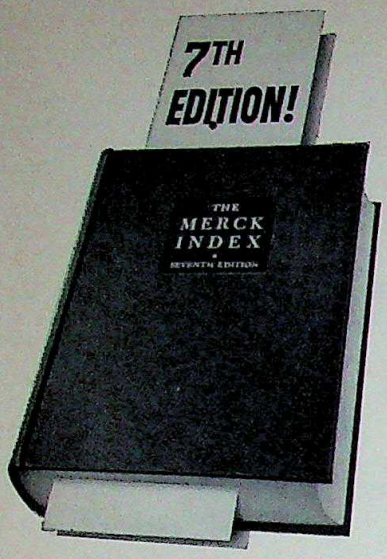

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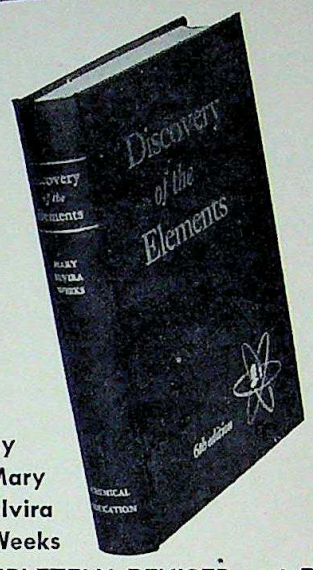

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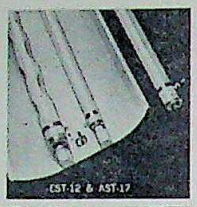

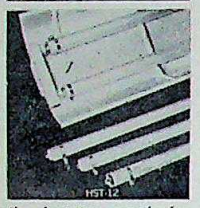

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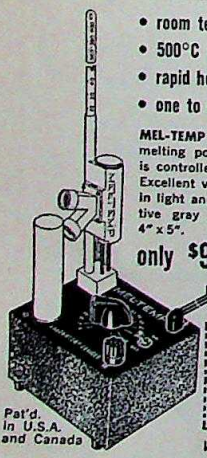

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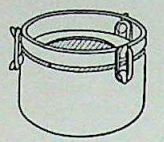

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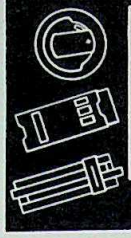

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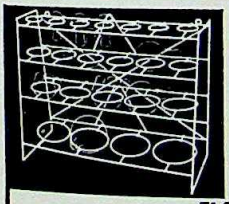

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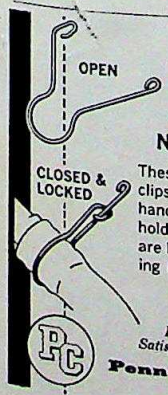

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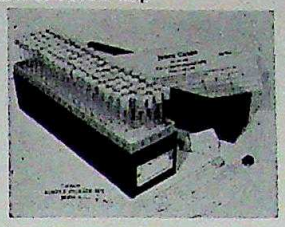

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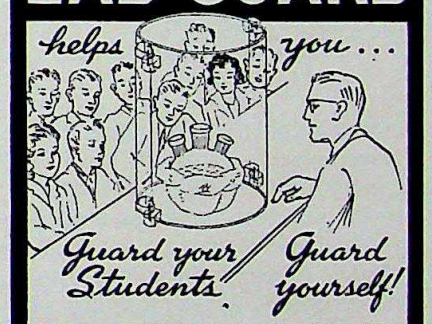

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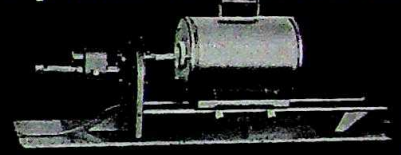

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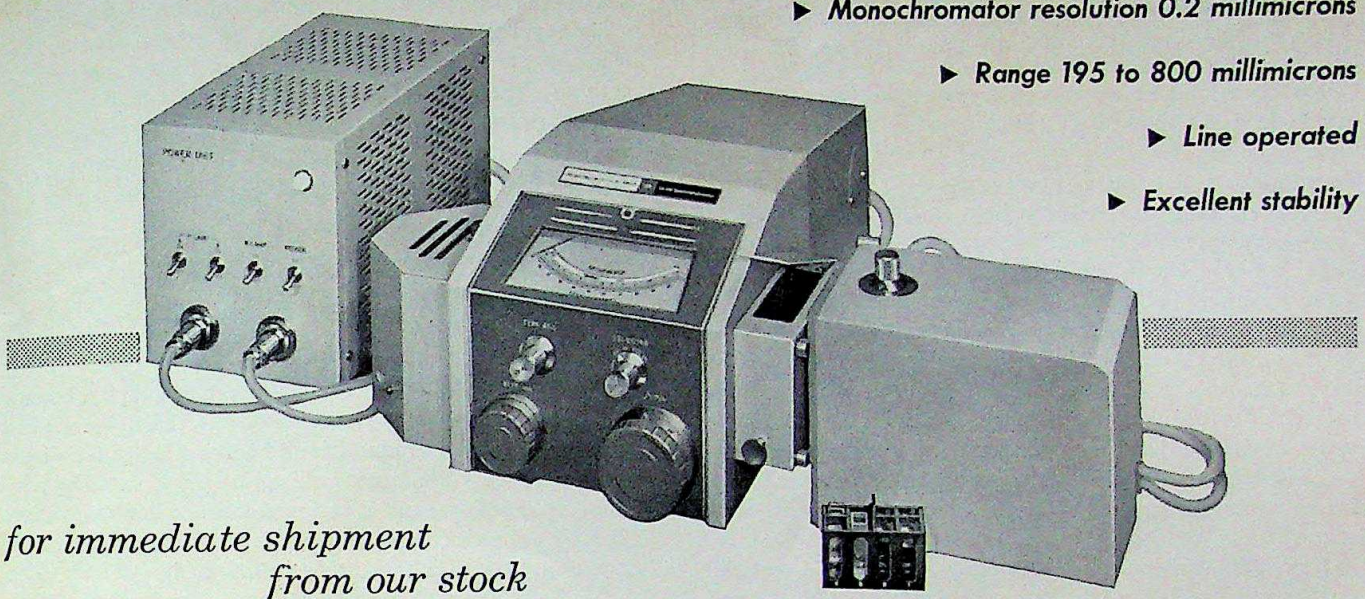

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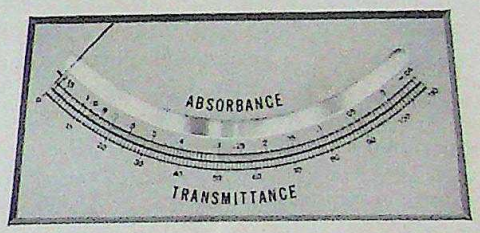

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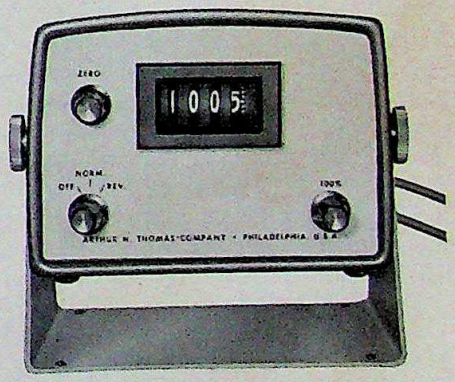

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Bobbitt:
THIN LAYER CHROMATOGRAPHY

by JAMES M. BOBBITT, Assistant Professor of Chemistry, University of Connecticut. 6 × 9. 1963. 250 pp., $8.50

-No aspect of analytical chemistry has made more dramatic strides in recent years than chromatographic techniques. This new book on thin layer chromatography is compiled and organized in such a way as to keep pace with increasing interest and widening usage. It has been designed to serve those just beginning to apply TLC to their problems, as well as to provide a complete reference encompassing current data and basic material. Because of the rapidly attained popularity of TLC in Europe, standardized adsorbent and equipment have become available commercially. It has become important to have a knowledge of appropriate "sets"—as well as their sources. To provide the knowledge, and to further the application of theory, the author discusses each experimental technique in detail—covering procedures, types, various binders—listing numerous reagents with specific directions for preparation.

Now it is possible to find previously unattainable material on: preparing the layers; such parameters as thickness and moisture contrast; various glass plates used; a comparative analysis of various commercially available apparatus given (with sources)—accompanied by detailed drawings; descriptions of layer preparation, with directions. The contents also include making the separations: general requirements for separation vessels and sources; application of the mixtures to be separated; development of the chromatograms, reliability of Rf values in various systems. The section on analysis of the results covers spray reagents, other methods for making the compounds visible, and component isolation. Applications include types of problems which can be solved: specific applications, organic, biochemical, and inorganic.

-In addition to theoretical considerations, the history of the development of the method of thin layer chromatography is outlined with the persons involved cited. There is full consideration of the new application of chromatographic analysis. Not only are the advantages and disadvantages of this recently discovered technique carefully weighed, but its relation to other forms of chromatography are projected within the framework of the entire subject as a whole.

Heftmann:
CHROMATOGRAPHY

edited by ERICH HEFTMANN, National Institutes of Health, Bethesda, Maryland. 1961. 780 pages. $17.50

"Dr. Heftmann together with 33 outstanding research workers in the field of chromatography has compiled a book which deals equally with adsorption, ion exchange and partition chromatography, gas chromatography and zone electrophotesis. Each chapter is written by a different author, some chapters having been translated by Dr. Heftmann. The book will be invaluable for anyone teaching or learning chromatographic methods, as it presents a survey of most of the possibilities of this technique. It can also be recommended as a handbook in certain fields. The text is richly illustrated, well printed and some chapters list good selections of Rf values and Electrophoretic mobilities."—Journal of Chromatography

The first half of the book contains an authoritative development of the theories and techniques of chromatographic methods; the second half deals with the applications to important classes of compounds. A wealth of references to current papers, books and review articles is included.

Stock and Rice:
CHROMATOGRAPHIC METHODS

by R. STOCK and C. B. F. RICE. 1963. Approx. 250 pp., $10.00

With emphasis on paper and gas chromatography, because these methods are now the most important, this well-organized book serves as an introduction and accounting of techniques currently in use. The treatment is primarily dictated by practical considerations, and is designed to show how the various methods complement each other. In addition to this wealth of practical detail is the extensive knowledge which reflects the authors' personal experience over a long period of time. One important and invaluable feature is the inclusion of a group of single experiments covering the whole range of methods described, especially students' experiments in gas chromatography which is regarded as an important development. Zone electrophoresis, while not strictly speaking a chromatographic technique, is nearly enough related to be included. The reader can find guidance as to the choice of method for a particular purpose, and to assess the relative value of the different procedures.

A book valuable to teachers in schools, technical colleges and universities, to final year undergraduates, and to analytical and industrial chemists and biochemists who want an introduction to chromatography.

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Topics in . . .

Chemical Instrumentation

. . . a Chem Ed feature

Edited by **S. Z. LEWIN,** New York University, New York 3, N. Y.

These articles, most of which are to be contributed by guest authors, are intended to serve the readers of this JOURNAL *by calling attention to new developments in the theory, design, or availability of chemical laboratory instrumentation, or by presenting useful insights and explanations of topics that are of practical importance to those who use, or teach the use of, modern instrumentation and instrumental techniques.*

XII. Pressure Measurement. Part Two

Seymour T. Zenchelsky, *School of Chemistry, Rutgers University New Brunswick, N. J.*

The preceding installment dealt with liquid-column gages; this one treats mechanical and thermal gages.

Mechanical Gages

One great disadvantage of liquid-column gages is the fact that chemical reactions may occur between the manometric liquid and the gas whose pressure is being measured. In the case of mercury, the solid products of such reactions frequently deposit on the inner walls of the tubes and reduce the accuracy of measurement. This is the reason for the great concern with ease-of-cleaning as a feature in the design of such devices. Mechanical gages, on the other hand, eliminate the manometric liquid, exposing to the gas a solid surface which can be metal, glass, or quartz.

Such gages depend upon the distortion of the solid surface when unequal pressures are exerted on its two sides, thus these gages may be used as either absolute or differential manometers. Since at equilibrium the forces acting on both sides of the surface must be equal, it follows that the sensitivity of the gage will increase with increased surface area. Four types have been used: (1) the Bourdon tube, (2) the bellows, (3) the capsule, and (4) the diaphragm. These are illustrated in Figures 15, 16, 17, 18, and 19. For sufficiently large pressure-differentials, the distortion may be measured by means of the displacement of a pointer which is linked mechanically to the surface, otherwise displacement transducers are needed.

Bourdon Tube. The basic Bourdon tube consists of a length of tubing, elliptical in cross-section, which is bent into an arc and sealed at one end. If the open end is connected to a source of high pressure, the cross-section of the tube will tend to become more nearly circular, resulting in an increase of the radius-of-curvature of the arc. Thus, if the open end of the tube is constrained, the closed end will be displaced. Greater sensitivity is obtained by increasing the length of the Bourdon tube in order to increase its area, but space is conserved by winding the tube into a spiral or helix (Fig. 20 and 21). The effect of barometric pressure (on the outside of the Bourdon tube) is either compensated by the use of a second Bourdon tube, which is open to the atmosphere, or eliminated by sealing the instrument case at fixed pressure.

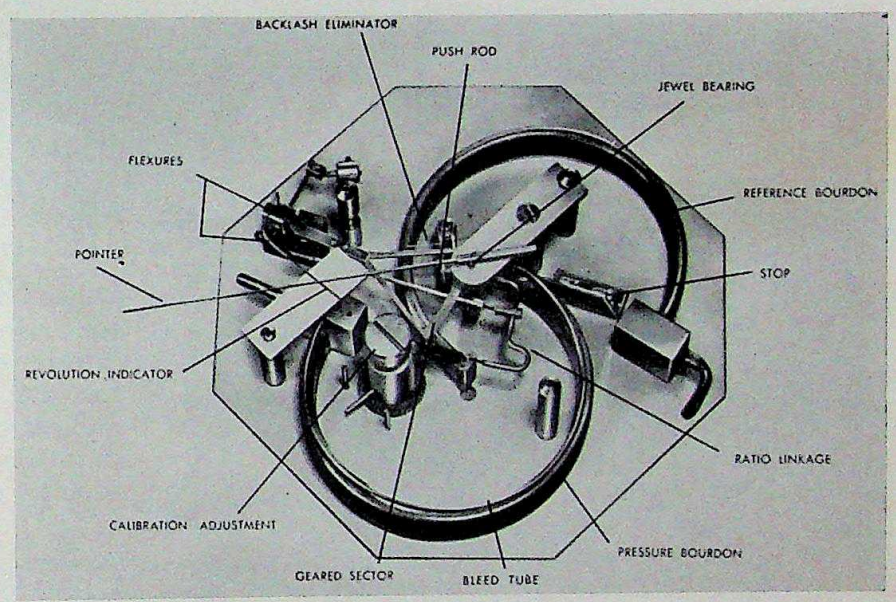

Figure 15. Wallace and Tiernan Bourdon-tube gage mechanism.

Bourdon tubes are less sensitive than the other mechanical pressure-sensing devices, and are normally used for measurements above one-atmosphere (approximately 760 mm Hg). Direct-reading gages are available from many laboratory-supply companies, with Bourdon tubes made of various metals and alloys (Fig. 22). More sensitive Bourdon-gages, made of glass or quartz, are available from fabricators of custom laboratory-glassware. The Worden gage (Worden Laboratories, Houston 27, Texas) consists of a quartz helix which possesses a sensitivity of 360-degrees of rotation per atmosphere (Fig. 23). This motion may be followed either by observing an attached pointer through a microscope or by observing the displacement of a light-beam which is reflected from an attached mirror. The latter method provides greater sensitivity through the available optical leverage.

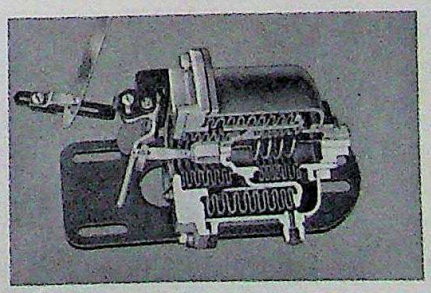

Figure 16. Taylor Instrument absolute-pressure bellows element.

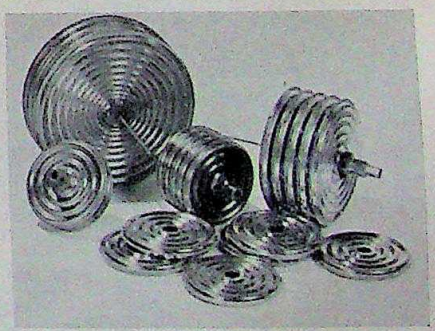

Figure 17. Bristol capsular measuring element.

(*Continued on page A774*)

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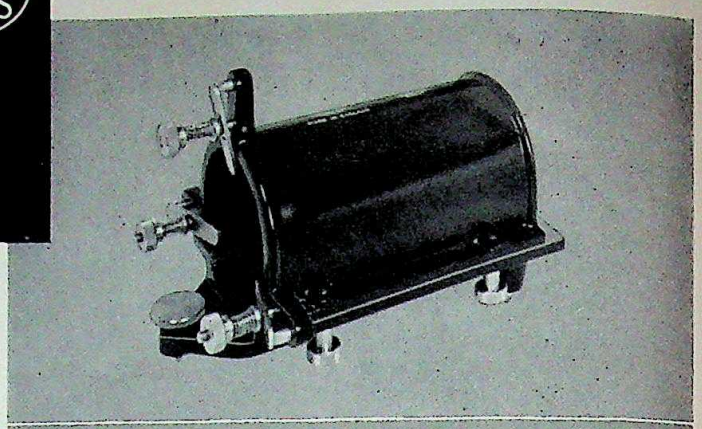

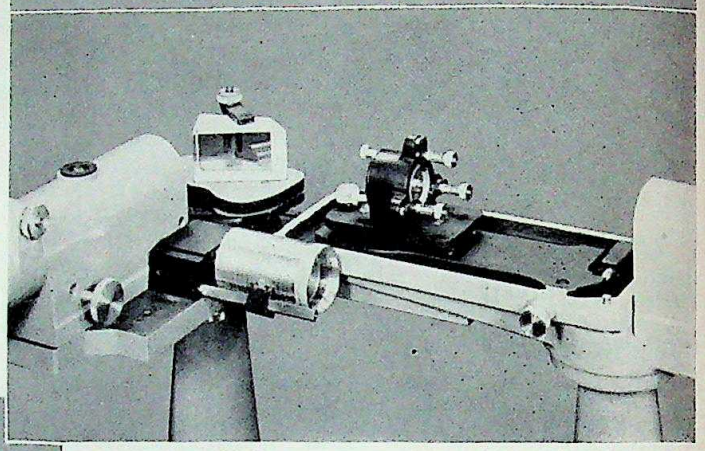

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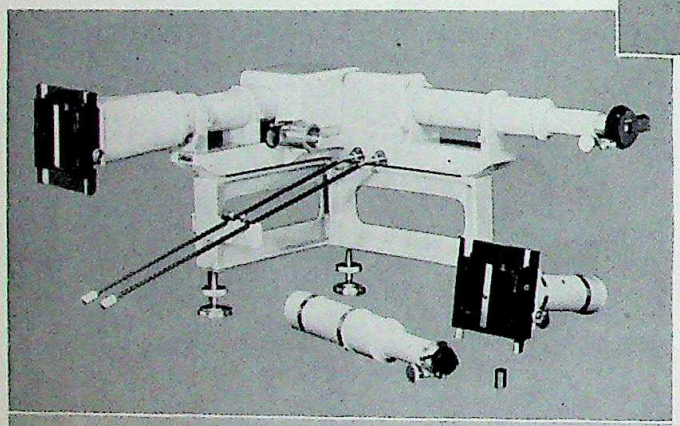

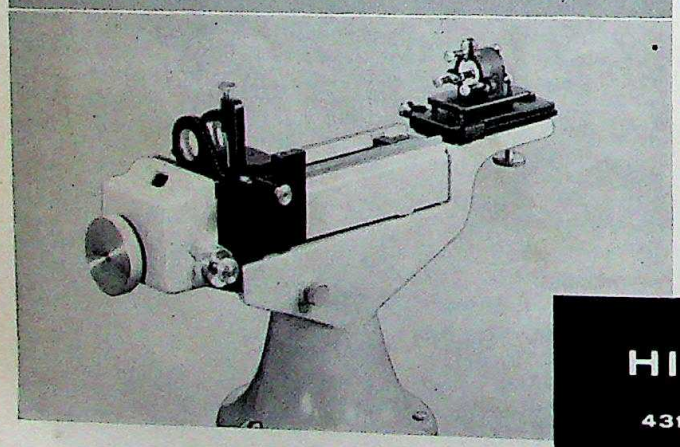

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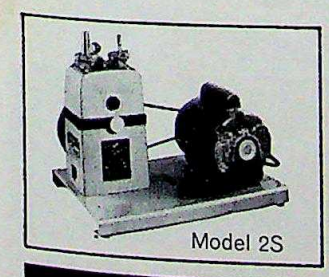
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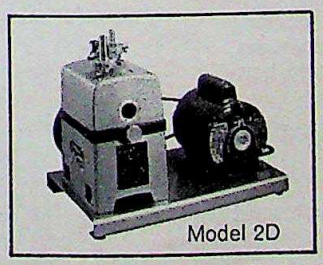
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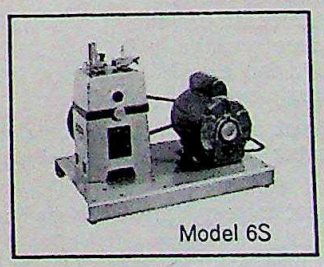
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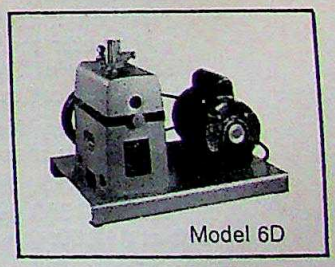
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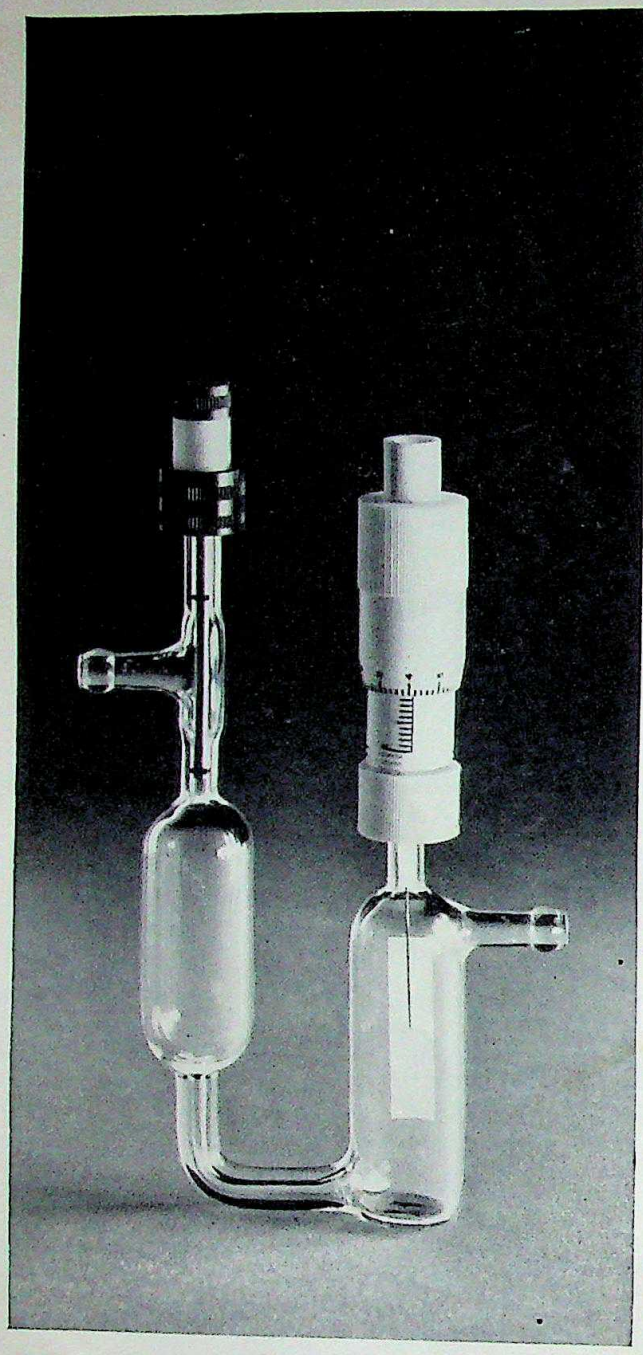

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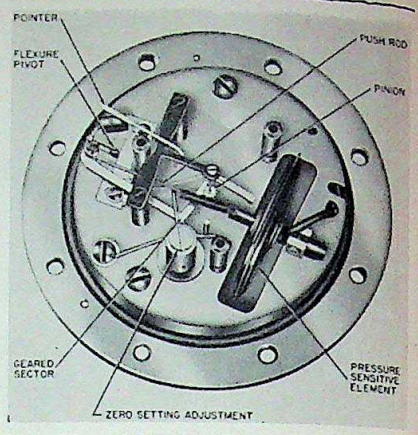

Figure 18. Wallace and Tiernan capsular gage mechanism.

Bellows, Capsules, and Diaphragms. These mechanical pressure-sensing devices are successively more sensitive than Bourdon tubes. In fact, a diaphragm-type described by Stewardson[1] possesses a sensitivity of 10^{-4} mm Hg. But commercially available devices are generally

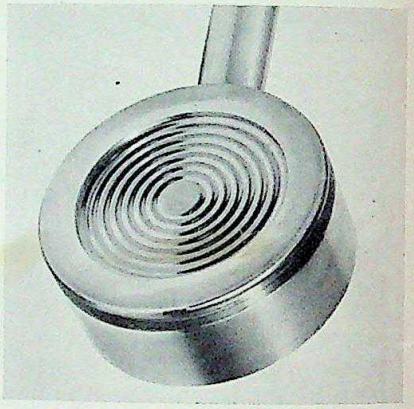

Figure 19. Taylor instrument diaphragm element

less sensitive. They are available from various manufacturers of recording and control instruments (The Bristol Co., Waterbury 20, Connecticut; Fischer and Porter Co., Warminster, Pennsylvania; Minneapolis-Honeywell Regulator Co., Brown Instruments Division, Philadelphia 44, Pennsylvania; Taylor Instrument Co.,

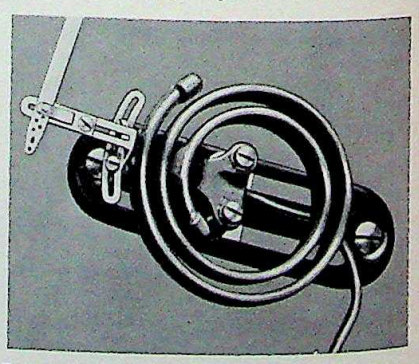

Figure 20. Taylor instrument spiral Bourdon-tube element.

Rochester, New York; Wallace and Tiernan, Inc., Belleville 9, New Jersey).

Direct-reading gages, with good sensi-

(Continued on page A776)

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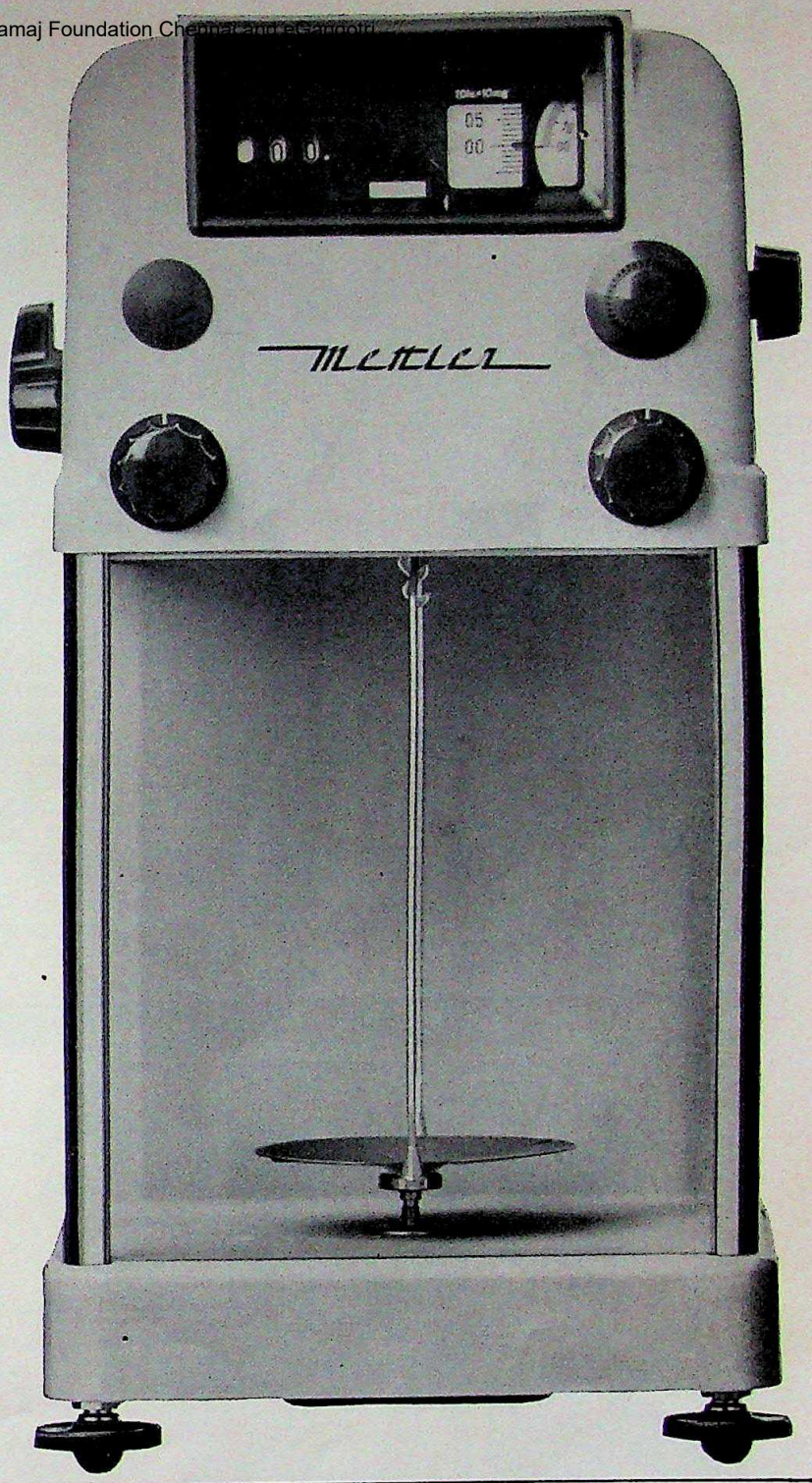

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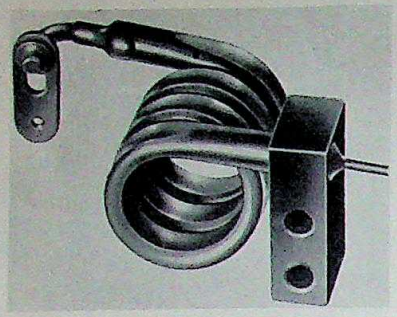


Figure 21. Taylor instrument helical Bourdon-tube element.

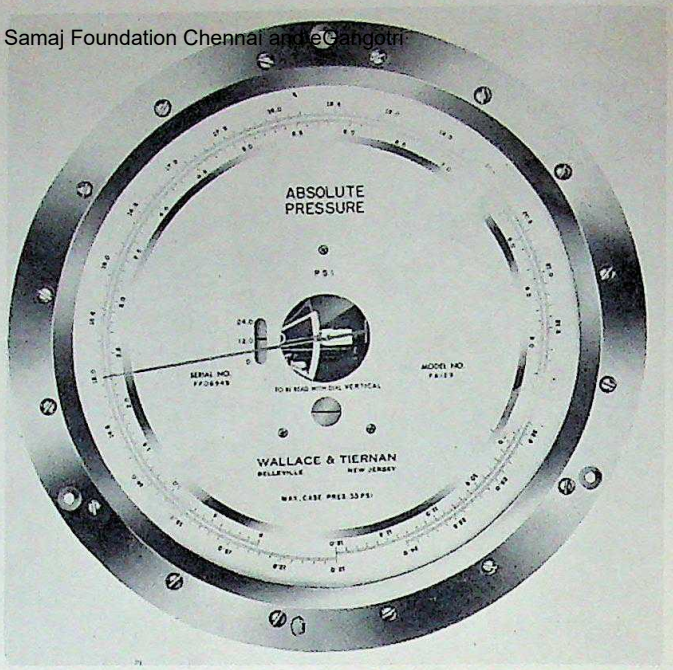


Figure 22. Wallace and Tiernan Bourdon-tube gage.

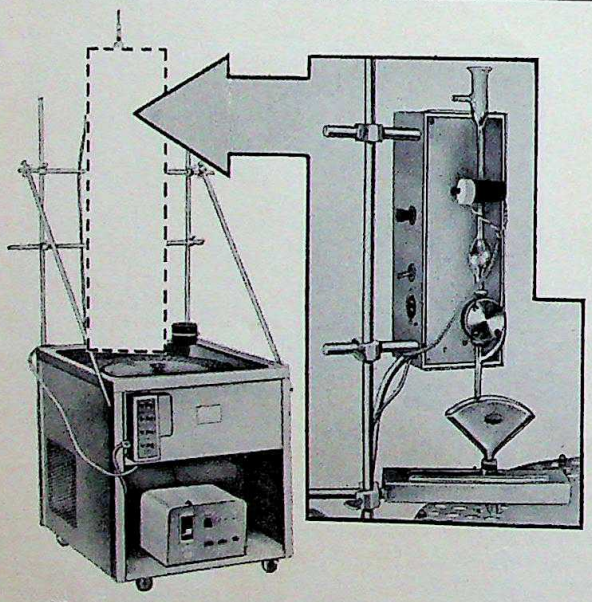
tivity, are available from Wallace and Tiernan, Consolidated Vacuum Corp. (Rochester 3, New York), and Arthur F. Smith, Inc. (Rochester 4, New York). Two of these are shown in Figures 24 and 25. The Wallace and Tiernan Absolute Pressure Indicator is available with a range of 0.1–2 mm Hg and with graduations of 0.1 mm Hg. It has an accuracy of 0.33% of full-scale range.

Recording and Control. Mechanical gages possess a second advantage over liquid column gages: they lend themselves more readily to continuous indication, recording, and control. For these purposes a variety of displacement transducers is used; some of them are described below.

The Texas Instruments Precision Pressure Gage (Texas Instruments, Inc., Houston 6, Texas) uses a fused-quartz Bourdon-helix with attached mirror (Fig. 26). Displacements are detected photoelectrically, resulting in the unbalance of a bridge circuit. By manually balancing the bridge, a sensitivity of 1×10^{-4} atmosphere can be achieved over the range 0–1 atmosphere. A digital readout minimizes reading errors (Fig. 27). The instrument has recorder terminals for continuous monitoring of the bridge unbalance.

In the Fischer and Porter Press-I-Cell Indicator (Fig. 28), the Bourdon-spiral (or capsule) is attached to an iron rod which forms the core of an inductance coil. Motion of the rod results in the unbalance of an a.c.-bridge, with the consequent restoration of balance by means of a servo system. This instrument is available in the ranges, 0–800 mm Hg (absolute)

(*Continued on page A778*)



Illustrated: A Buchler Refrigerated Model (the "mobile cold room"), cooled from column to test tubes. Complete line of 25 models including short-run, continuous, sectional or special purpose fraction collectors described in **Bulletin J 3-4000.**

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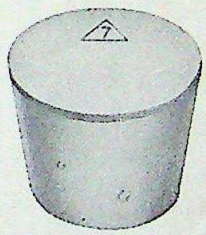
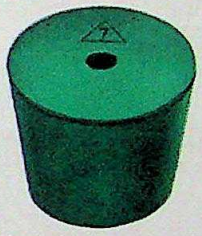


GRADE #M18 PURE GUM



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ranged 0–200 mm Hg (differential). In both cases the error does not exceed $^1/_{1000}$ of full-scale range.

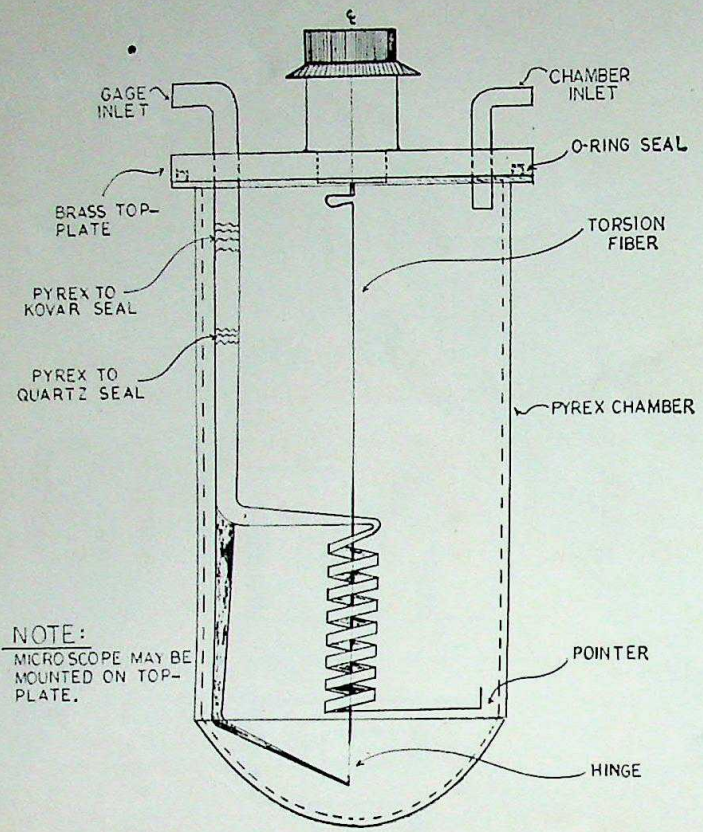

Figure 23. Worden Laboratory Bourden gage-torsion fiber nulling type.

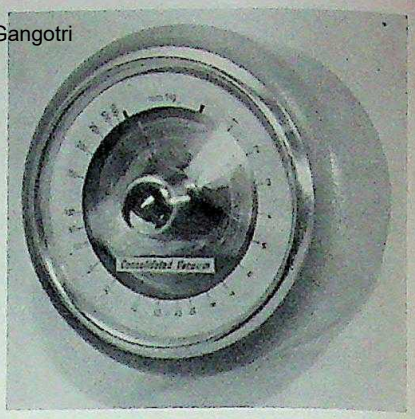

Figure 24. Consolidated Vacuum diaphragm gage.

Absolute Pressure Potentiometers (Bourns Laboratories, Riverside, California) consist of evacuated capsules which are mechanically linked to a slidewire potentiometer (Fig. 29). They are available in the range, 0–2 lb/in.^{2} (approximately 0–100 mm Hg), with a resolution of 0.25% of full-scale range and an accuracy of 0.5% of full-scale range. A differential pressure-potentiometer covering the range, 0–1 lb/in.^{2}, with similar accuracy, is also available. These devices can be obtained in several resistance ranges, and their outputs vary linearly with pressure to within 1% of full-scale range. For higher pressures, a Bourdon-tube potentiometer is also available.

Pressure-transducers, consisting of

(*Continued on page A780*)

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- Separate preheater (injection port), column, and cell compartments.
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strain-gage elements which are attached to a sensitive metal-diaphragm, are available from Consolidated Electrodynamics (Monrovia, California) and Data Sensors, Inc. (Gardena, California). Absolute and differential ranges as low as 5 lb/in.^{2}

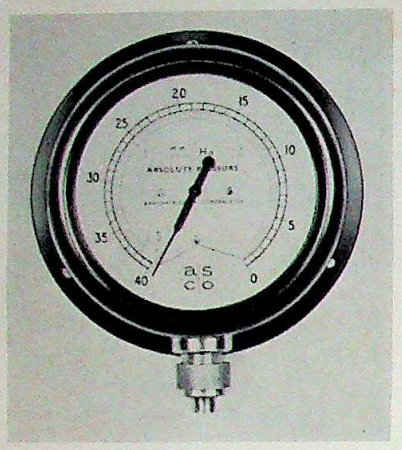

Figure 25. Arthur F. Smith capsule gage.

(approximately 250 mm Hg) can be obtained. These devices employ a Wheatstone-bridge circuit in order to compensate for temperature variations. Output is linear with pressure to within 1% of full-scale range (Fig. 30).

Indicating and recording gages of various kinds are available from the manufacturers of recording and control instruments who were listed above.

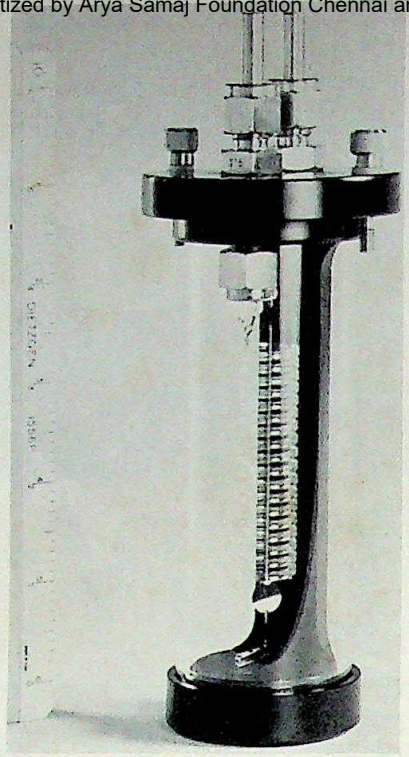

Figure 26. Texas Instruments fused-quartz Bourdon element.

Pressure-sensitive Paint. A pressure-sensitive paint is available from Clark Electronic Laboratories (Palm Springs,

Figure 27. Texas Instruments precision pressure gage.

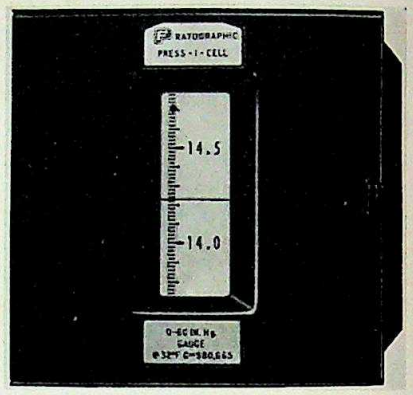

Figure 28. Fischer and Porter Press-I-Cell indicator.

(*Continued on page A782*)

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To give you more convenient, accurate readings, Torsion has designed the PL-1 with a fine-reading vernier to 1/10 gram and a capacity of 1 kilogram. The balance has an optical range of −10 grams to +110 grams.

The heart of the mechanism in the new PL-1 is the Torsion no-knife edge construction. This eliminates friction and wear, insures lifetime accuracy and speeds weighing. The balance will operate accurately even in severely corrosive or dust-laden atmospheres.

Taring through a 125 gram range is accomplished with a built-in knob on the side of the balance. By using the second pan the balance can be made to tare up to 325 grams. Torsion's optical projection Model PL-1 offers a sharp image with a high degree of illumination for easy reading and an oil damper to speed up weighing.

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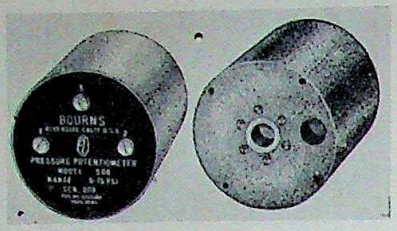

Figure 29. Bourns Laboratroies pressure potentiometer.

California) and forms the basis for its Absolute Pressure Transducer. This instrument consists of a sandwich of the paint (between a pair of metal discs). Since the resistance of the paint changes with pressure, the device acts as a differential manometer (or as an absolute manometer when the reference pressure is zero). Although this transducer defies classification according to the scheme given in Part I, its listing among mechanical gages appears reasonable.

Figure 30. Consolidated Electrodynamics strain-gage pressure transducer

The Clark Absolute Pressure Transducer is sensitive from approximately 800 mm Hg down to 15 mm Hg, exhibiting a resistance variation of 4×10^5 ohms over this range.

Thermal Gages

Thermal gages depend upon the fact that the heat conductance of a gas varies with its pressure. Thus the temperature of a heated surface, which is surrounded by gas, will decrease with increased gas pressure. These are, therefore, gages of the third kind: they depend upon the kinetic-molecular behavior of gases. Their

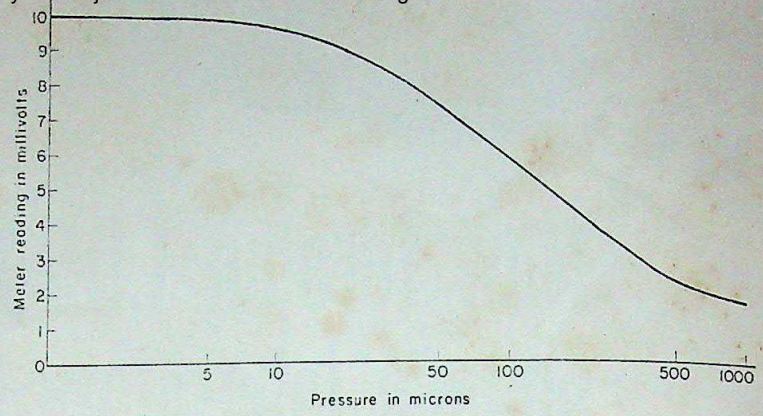

Figure 31. Elion Instruments DVT-6 thermocouple gage-tube characteristics.

Figure 32. Consolidated Vacuum thermocouple gage.

(Continued on page A788)

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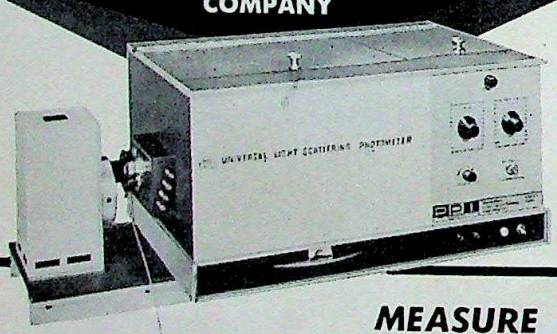

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NEW BRICE-PHOENIX UNIVERSAL LIGHT SCATTERING PHOTOMETER
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Measures:
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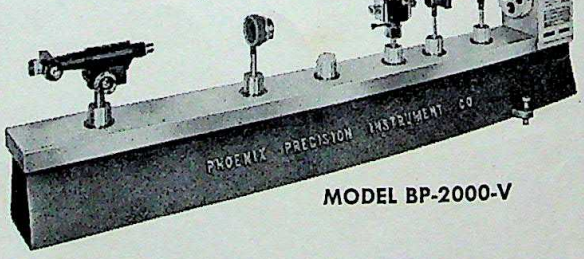

MODEL BP-2000-V

The New Brice-Phoenix Differential Refractometer uses a split cell to measure the difference in refractive index between a dilute solution and its solvent.

Sensitivity 3×10^{-6}.

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moduline

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Hy-Fl2 • 202 • 1520

How can you design a gas chromatograph and protect heat-sensitive electronic components from the oven heat? One cumbersome method is to build two separate units.

A separate cabinet fan in a single, compact unit is the approach used in the new Aerograph Moduline Series.

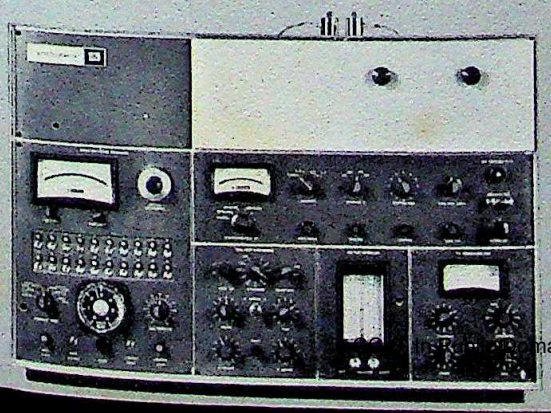
Three sparkling models were developed.

THE "Hy-Fl2" is a single-column instrument which adapts perfectly to: Flame, Electron Capture, Cross Section and Thermal Conductivity detectors. Manual or linear temperature programming modules are optional.

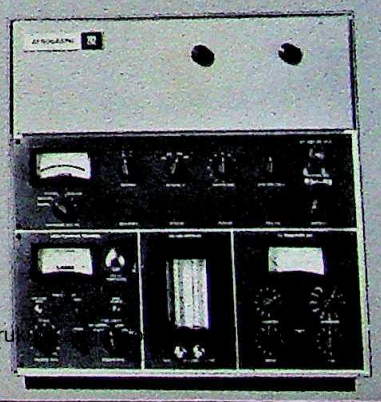
THE "202" is a two-column instrument adaptable to both Dual Flame and Thermal Conductivity detectors. Manual or linear temperature programming modules are optional.

THE "1520" is a deluxe version of the 202 equipped with both Dual Flame and T.C. detectors. It features matrix board temperature programming, automatic cooldown, and automatic reset-to-start temperature.

The 1520



The 202



The Hy-Fl2

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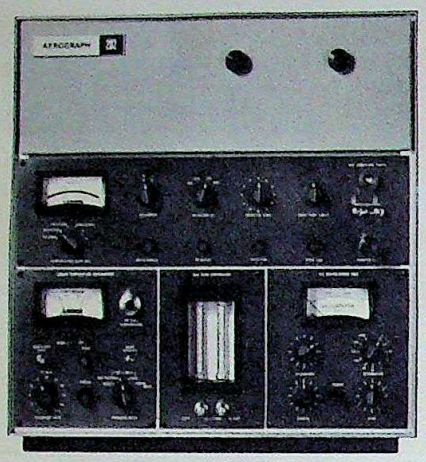
The 202



FEATURES

- Dual-column with either flame or T.C. detectors
- Linear or manual programmer modules
- Automatic oven cool-down (with LP)
- Dual input electrometer or bridge modules
- On-column or flash vaporized injection
- Separately heated detector oven

ORDER:

1. 202—FL/MP—dual flame—manual programmer
2. 202—TC/MP—thermal conductivity—manual programmer
3. 202—FL/LP—dual flame—linear programmer
4. 202—TC/LP—thermal conductivity—linear programmer

THEORY

The concept of two-column gas chromatography was first introduced by Drs. Edward M. Emery and W. E. Koerner, Monsanto Chemical Co., at the 1961 Spring ACS Meeting.

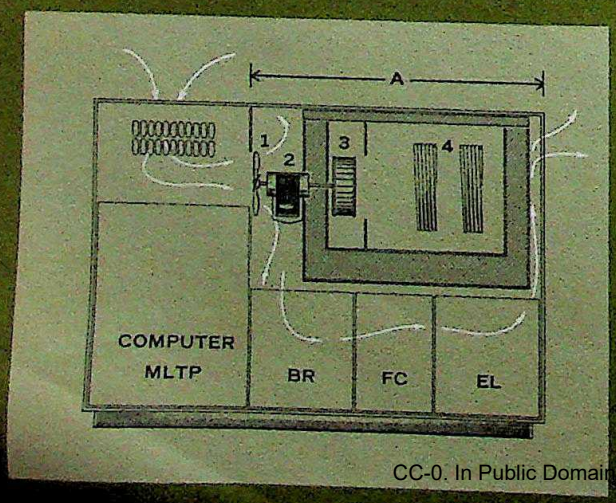
At about this same time we introduced the Aerograph A-350 featuring dual-columns connected to a four-filament T.C. cell and having separate injectors for each column. The basic advantages of the two-column system are:

1. Column bleed compensation is provided by using one column as a blank.
2. Different column packings give the chemist immediate use of two-type columns such as polar and non-polar.

Two new basic dual-column gas chromatographs, 202 and 1520, have been developed. Both instruments have flow controllers, flow meters, and long tapered metering valves for controlling gas flow to each column.

The separate detector oven is carefully regulated at four set temperatures. The all stainless steel column oven, heated by a 800 watt coil, will program at 35°C/min to 400°C and will cool from 400 to 100°C in four minutes.

The Aerograph 202 incorporates either dual flame or dual input detectors. It may be used with the manual temperature programmer or the simple linear tempera-



MODULINE COMPONENTS

1	Fan for cabinet cooling
2	Synchronous motor, rubber-mounted
3	Fan for oven air circulation
4	Dual-column position
MLTP	Matrix linear temperature programmer
BR	Bridge/power supply for T.C. detector
FC	Dual flow controllers, flow meters and needle valves
EL	Dual input electrometer

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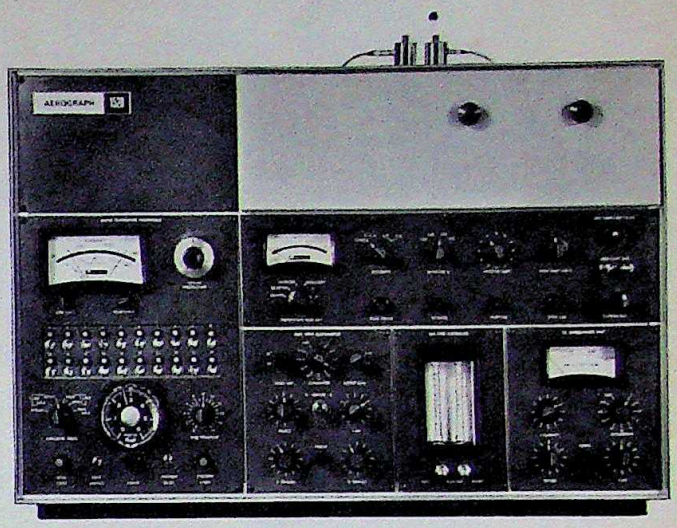
The 1520



PRACTICE

ture programmer (LP) modules. With the LP, oven cool-down is automatic but door-close is not. A manual switch operates the door at any time.

The 1520 is a more deluxe version of the 202. It contains both the dual flame and thermal conductivity detectors. The detector choice is made by re-connecting the downstream ends of the column. The exclusive Aerograph matrix temperature programmer is standard. This deluxe programmer not only gives complete flexibility in pre-setting temperature programming rates but automatically closes the oven door after cool-down and re-establishes the start temperature.

The injectors are independently heated. Temperature readout on an accurate, compensated pyrometer reads column oven, detector oven, injector, collector and auxiliary equipment plug. An automatic upper oven temperature limit control on all Moduline instruments protects columns and equipment from accidental overheating.

At lower right is shown a typical temperature program profile. The program rate may be caused to increase at any time during analysis or may be pre-set before the analysis. The programming rate is established by the resistance value of the matrix plugs . . . the time of change by their position on the matrix board.

At lower left is an interior view of the 1520 showing cabinet air cooling and modules. The 202 is identical to the "A" portion. Modules in this case would be either electrometer or bridge • manual programmer or linear programmer.

FEATURES

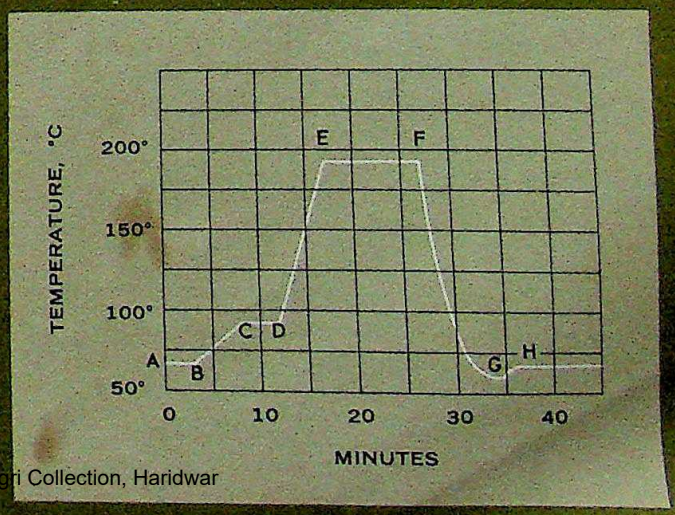
- Dual-column with both flame and T.C. detectors
- Matrix board temperature programmer
- Automatic oven cool-down and re-set to start temperature.
- Both dual input electrometer and bridge modules
- On-column or flash vaporized injection
- Separately heated detector oven

ORDER:

Aerograph 1520—dual column gas chromatograph with both dual flame and T.C. detectors. Flow controllers, electrometer, bridge/power supply and matrix temperature programming modules are standard.

MATRIX TEMPERATURE PROGRAMMER

A	Pre-set temperature—70°C.
A-B	Isothermal operation—@ 70°C for 3 min.
B-C	Linear programming—@ 5°C/min for 5 min.
C-D	Isothermal operation—@ 95°C for 4 min.
D-E	Linear programming—@ 20°C/min for 5 min.
E-F	Isothermal operation—@ 195°C for 10 min.
F-G	Door opens and oven cools down to 60°C in 7 minutes pre-set by timer.
G-H	Door closes and oven heats to pre-set temperature—70°C.



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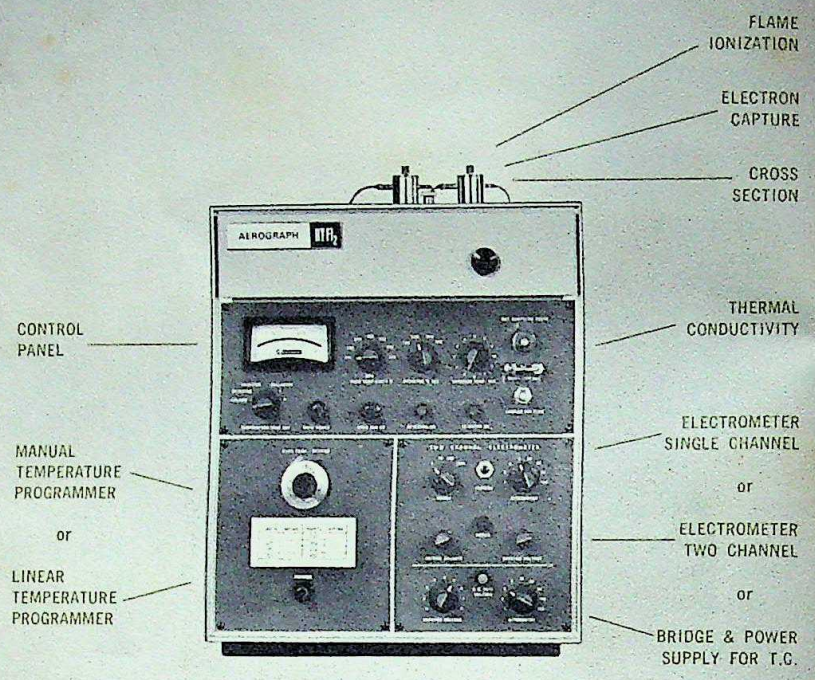
The Hy-Fl$_2$

The Hy-Fl$_2$, a big brother to the popular Hy-Fl 600-C, is a single column instrument which adapts perfectly to the three common ionization detectors and to the four-filament Thermal Conductivity detector.

Hy-Fl$_2$ Dual Channel

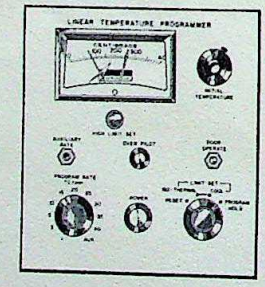
A further interesting option incorporates both flame and electron capture detectors. With this combination the column effluent is divided by a stream splitter to feed both detectors. The signals from both detectors are amplified by a two-channel electrometer which in turn operates a two-pen recorder. A striking trace of peppermint oil was made with this equipment. Many peaks were exhibited by electron capture which were not detected by the flame because of their low concentration. Please write for details.



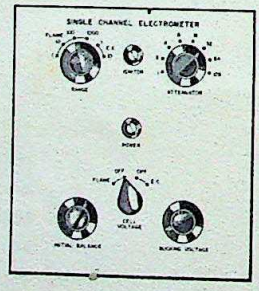
BONUS FEATURES

- Separate detector oven, heats to 400°C.
- 2" injector, stainless, separately heated.
- Variable power and thermocouple plug for auxiliary injection equipment.
- Stainless column oven, heats 40°C/min.
- Sample collection—capillary, with Flame Det.
- Carrier gas flow controller with long, tapered needle valve.

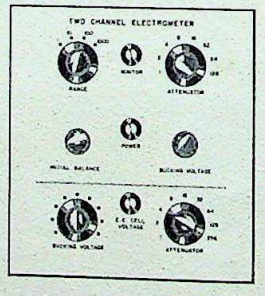
Manual Temperature Programmer—This unique controller supplies constant power to the column oven, by a solid-state electronic, adjustable power controller (APC) and multi-turn pot.



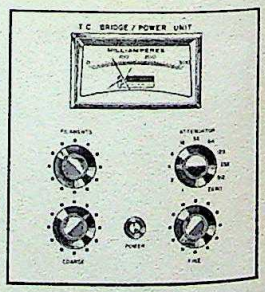
Linear Temperature Programmer—This programmer is completely electronic with no gears, motor or clutch. It programs at 10 precise rates. A matrix plug permits any additional rates.



Single Channel Electrometer—This high impedance electrometer used with single ionization detectors features 100% feedback, decade and binary attenuation and buckout control.



Two Channel Electrometer—This electrometer, with flame and electron capture combination, is actually two electrometers with one common power supply. It features 100% feedback and buckout on each channel.



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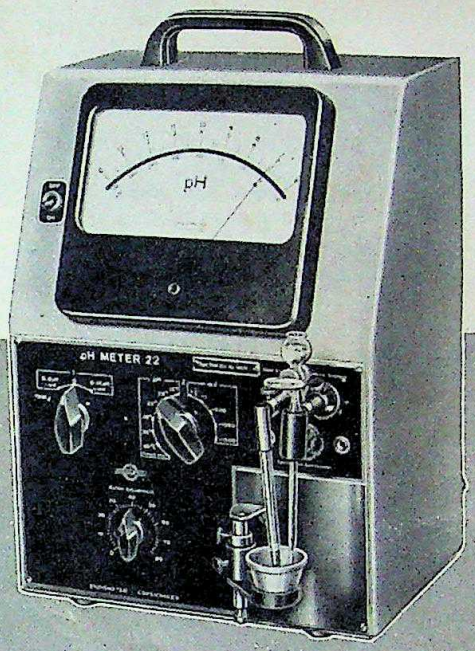
RADIOMETER pH Meter 22



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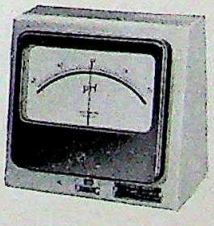

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sensitivity is low at high pressures, where the mean-free-path is small, and also at very low pressures, where the heat losses by conductance approach those resulting from radiation. Output is linear only over a small portion of the entire usable range, and the magnitude of the output is dependent upon the thermal conductivity of the particular gas being measured (Fig. 31). Thus, commercially available gages are usually calibrated with respect to dry air and require recalibration for other gases.

Basically, a thermal gage consists of a heated surface and a temperature-sensing device. Depending upon how the temperature-sensing is accomplished, the thermal gage is either a thermocouple-type or a resistance-type.

Thermocouple Gage. The simplest thermocouple gage is made by welding a thermocouple to the center of a wire which is heated. with constant energy-input, by means of direct current. Sensitivity may be increased by using a thermopile in place of the single thermocouple or by amplification of the thermocouple output. In either case, increased stability of energy-input to the heated wire is necessary.

Figure 33. Consolidated Vacuum thermocouple gage-tube.

Commercial thermocouple gages are available from many companies (Consolidated Vacuum Corp., Rochester, New York; NRC Equipment Corp., Newton Highlands 61, Massachusetts; F. J. Stokes, Corp., Philadelphia 20, Pennsylvania; The Fredericks Co., Bethayres, Pennsylvania; Elion Instruments, Inc., Burlington, New Jersey; General Electric Co., Schenectady, New York; Hastings-Raydist, Inc., Hampton, Virginia; Arthur F. Smith, Inc., Rochester 4, New York). These generally cover the range, 1–1000 microns (10^{-3}–1 mm Hg). Gage tubes are available from the above manufacturers for replacement when needed. Those of a given manufacturer are usually interchangeable without recalibration, if the heating current is set at the value indi-

(*Continued on page A792*)

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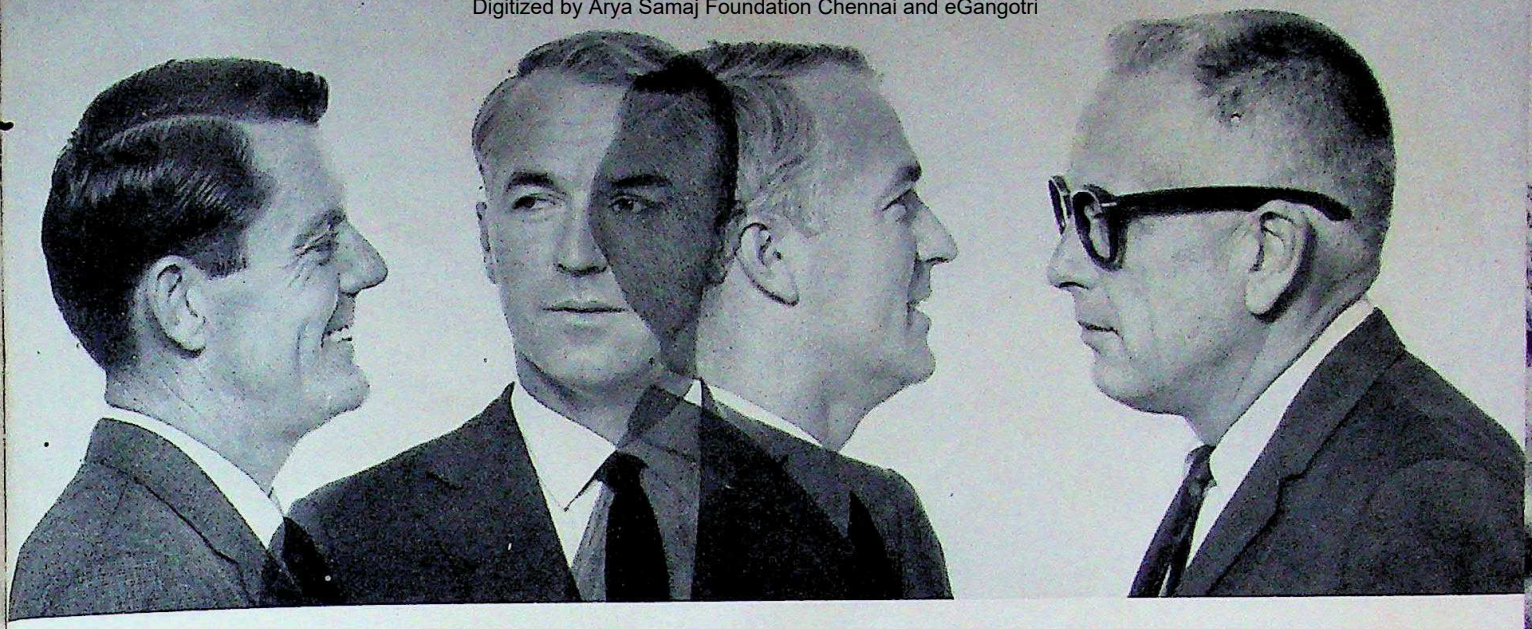

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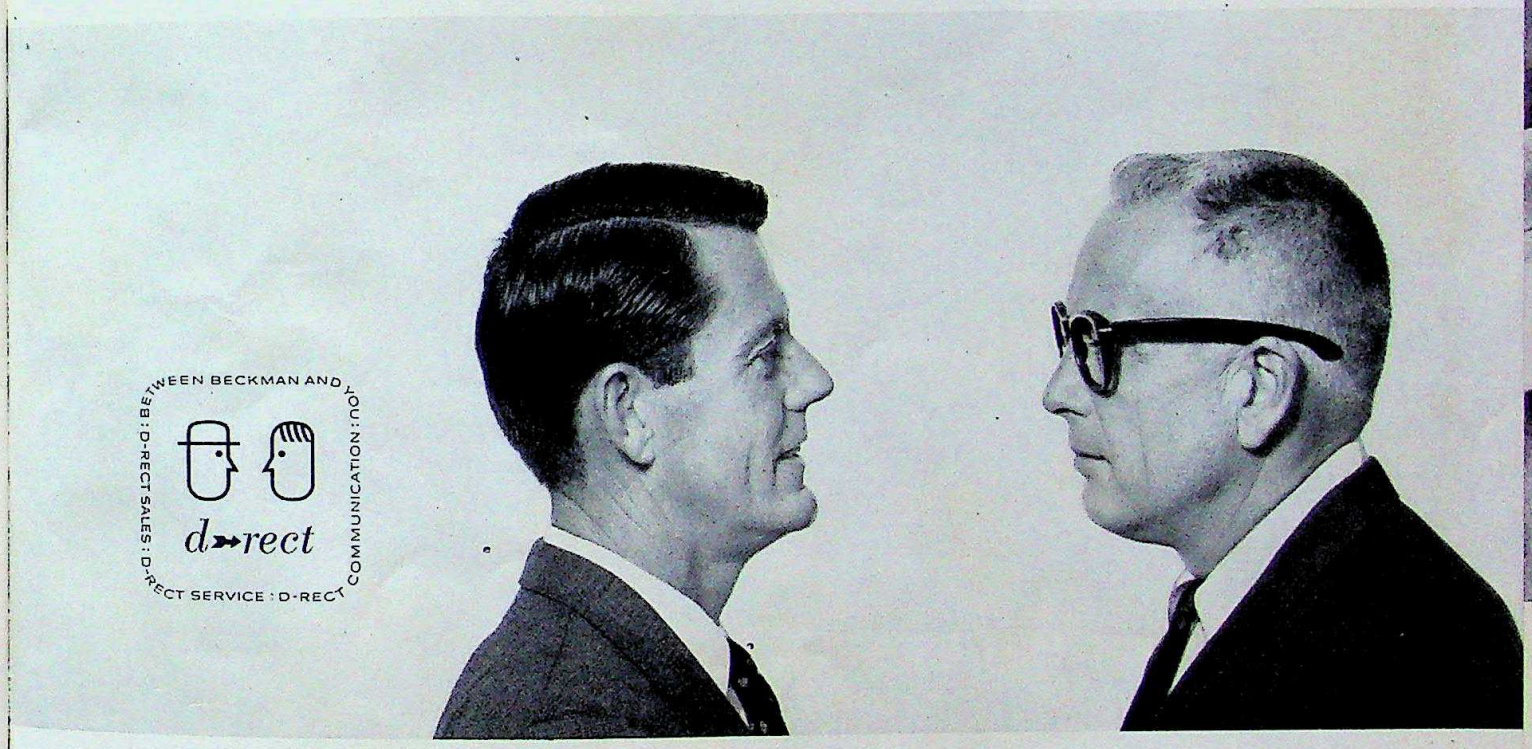

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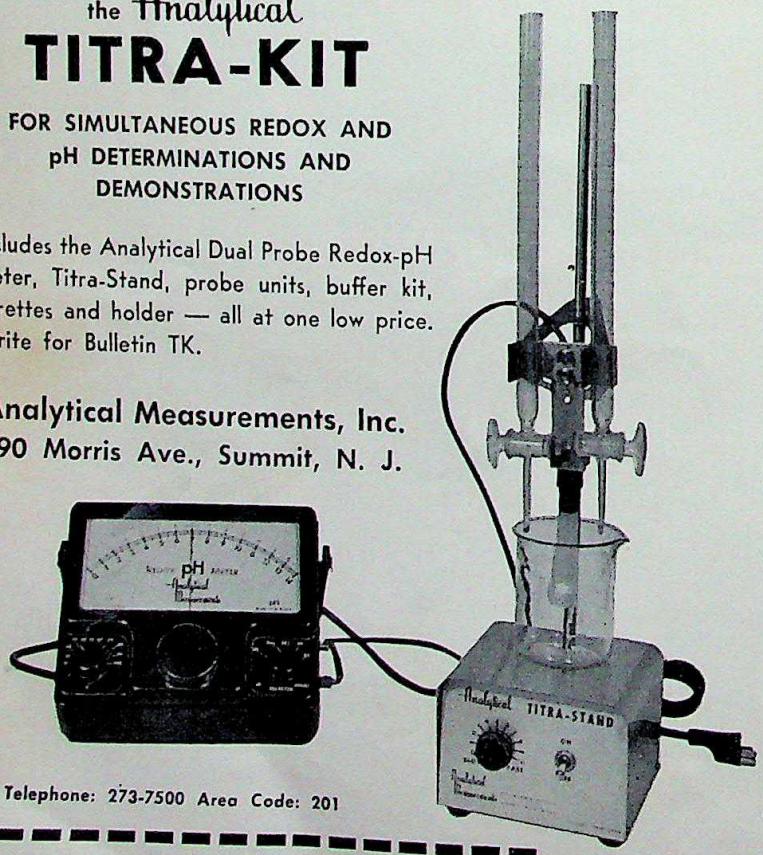

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cated on the tube. Some of the companies supply glass, as well as metal, tubes. The readout device can be a simple microammeter of low resistance. Portable models use a 1.5-v dry-cell to supply the heating current, which may be read on the microammeter by use of a scale-multiplier shunt.

Consolidated Vacuum Corporation manufactures several models, one of which is shown in Figure 32. It is powered by a single "D" flashlight battery. The metal gage-tube is shown in Figure 33; it uses Cupron and Chromel P for the thermocouple junction. Line-operated models are available for single-or multichannel operation as well as with relay control.

Several models are also available from NRC Equipment Corporation. Some of them are provided with recorder output-terminals; others are suitable for pressure-control. The Model 521 Thermocouple Gage Tube consists of a combination heater and thermocouple, which is shaped like a cross. It is made by welding the midpoints of two very thin wires, one of Advance and the other of Nichrome. The four ends are then welded to the base of a standard octal tube. This construction results in high shock-resistance and very fast response. A typical gage tube is shown in Figure 34.

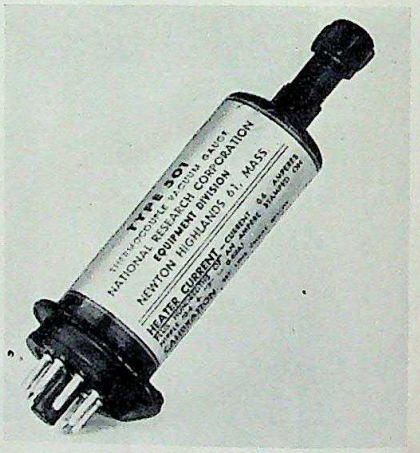

Figure 34. NRC thermocouple gage-tube.

The Stokes Vacuum Gage (Electrical Type) is available in three ranges, 0–100, 0–1000, and 0–20,000 microns, and with recorder or relay output-terminals (Fig. 35). The sensing element is a noble-metal thermopile which is heated by a constant ac, while the cold junctions are maintained at ambient temperature by heavy copper mounting-studs. Thus, the heated surface and the temperature-sensing device are combined into one.

The Elion Vacuum Gage, Model DVG-6, is available as a single-or multi-position unit, in cabinet or relay-rack mounting. It uses the Elion DVT-6, matched thermocouple-gage tube, which is of the noble-metal thermopile type. Despite rugged construction that reduces damage from vibration, the elements are so fine as to maintain the thermal time-constant below 0.06 sec.

(Continued on page A797)

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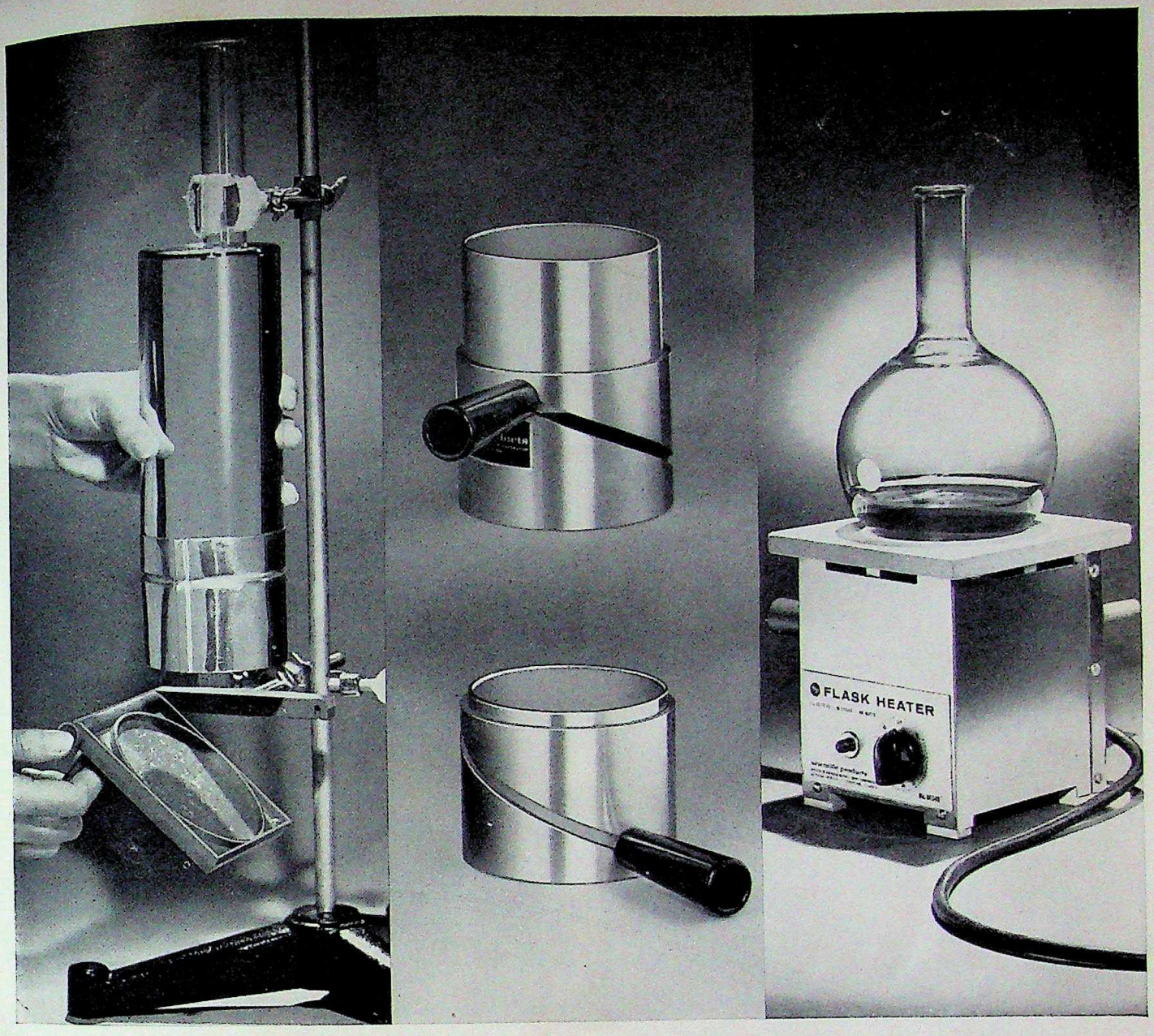

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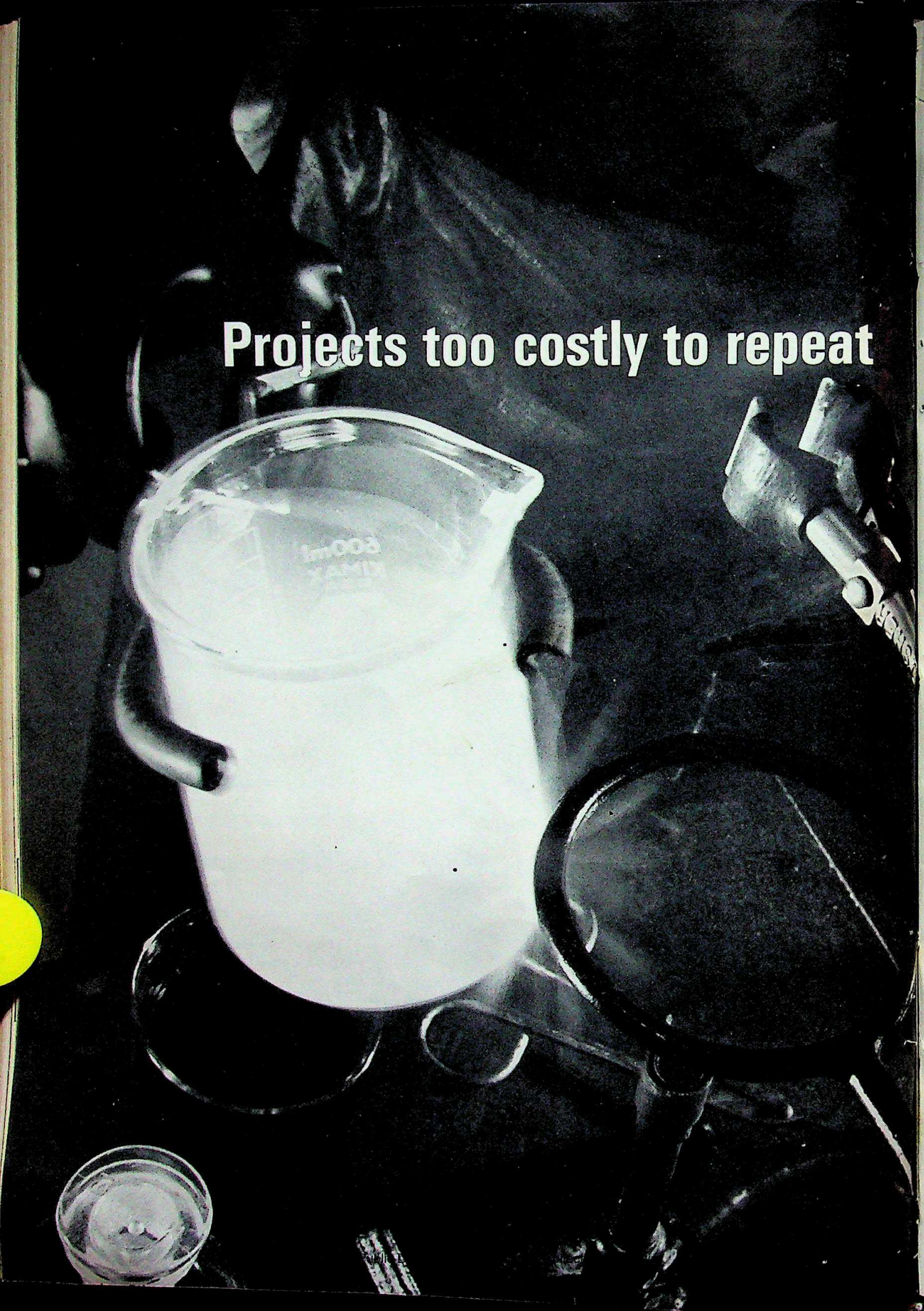
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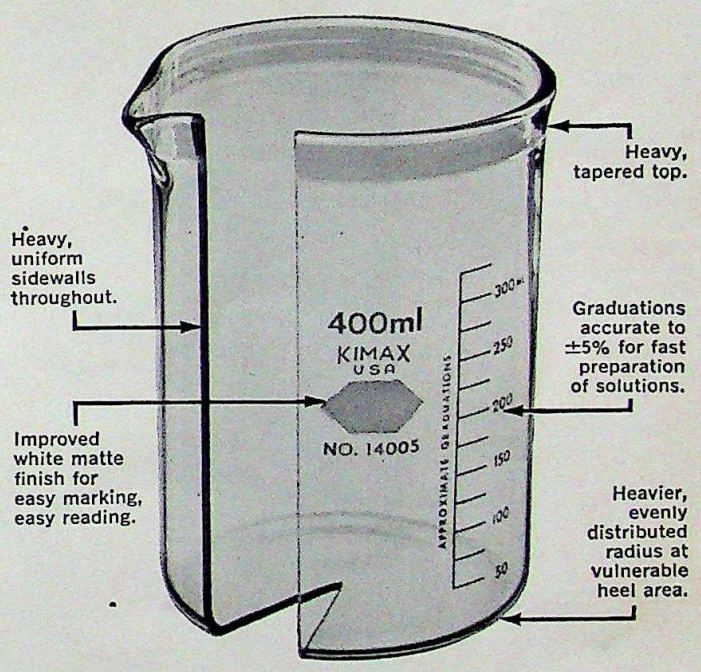

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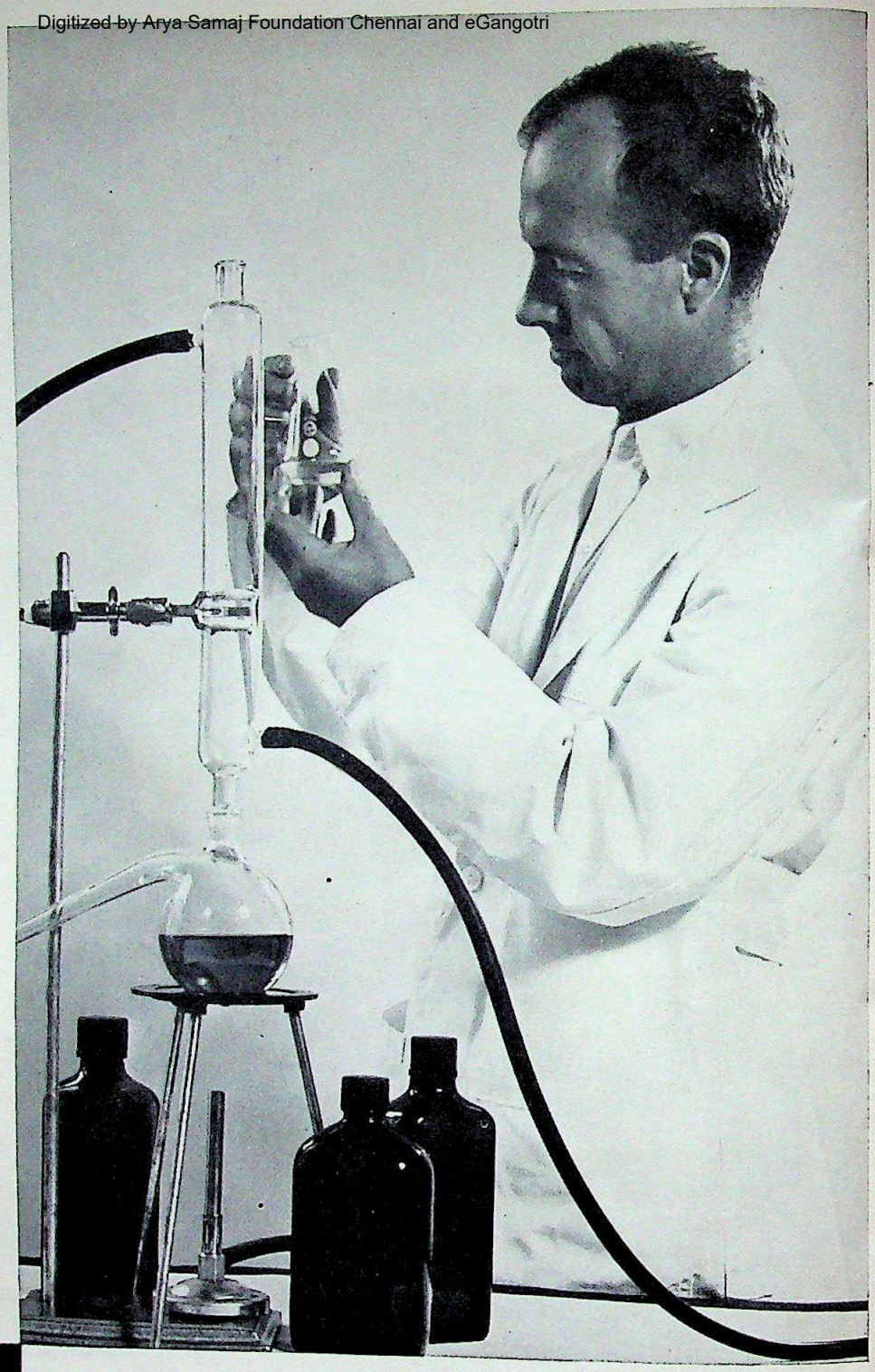

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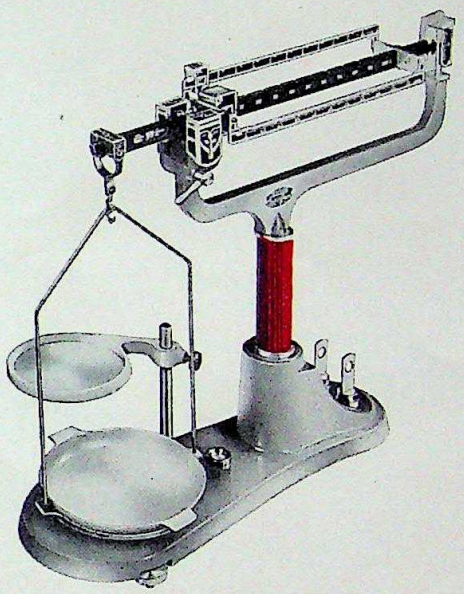

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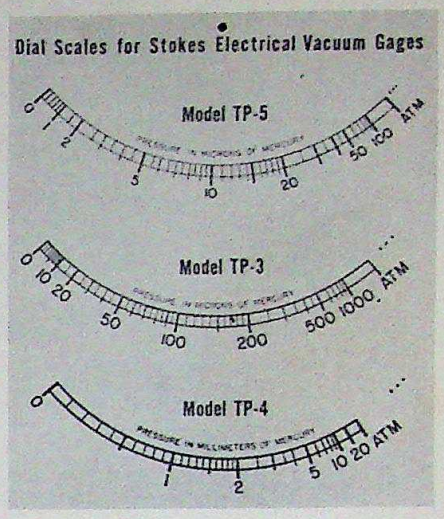

Figure 35.

Resistance Gage. In the resistance gage (Pirani gage), temperature is sensed by observing the resistance change of a metal or semiconductor, which usually forms part of a Wheatstone bridge. The bridge is excited by a voltage sufficiently large to cause self-heating of the resistance element, so that no auxilliary heated-surface is required. Ambient-temperature compensation can be obtained by using a second sensing-resistor, sealed in a good vacuum, in an adjacent arm of the bridge. The readout consists either of the bridge-unbalance voltage or of the current necessary to restore the bridge to balance. The latter may be accomplished automatically by means of a feedback network or servo system. These gages generally cover the range, 1–1000 microns.

Figure 36. Consolidated Vacuum Pirani gage.

Consolidated Vacuum Corporation supplies several models, including the unbalanced-bridge type as well as the self-balancing-bridge type. They are available for single or multiple-station operation as well as for recording and control (Fig. 36), with sensing tubes made of either metal or glass. Other Pirani gages are available from several sources: NRC Equipment Corporation; Hastings-Raydist, Inc.; Jelrus (available from Wilkens-Anderson Co., Chicago 56, Illinois).

The final section of this article will deal with ionization gages. A bibliography will be included with that section.

[1] STEWARDSON, E. A., *J. Sci. Instr.*, 7, 217 (1930).

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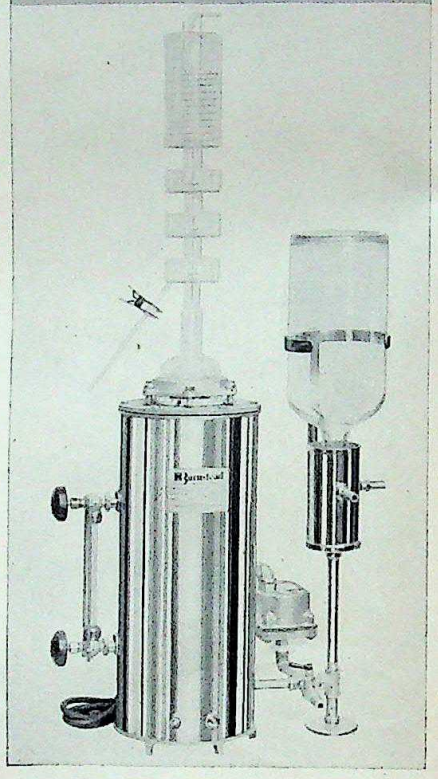

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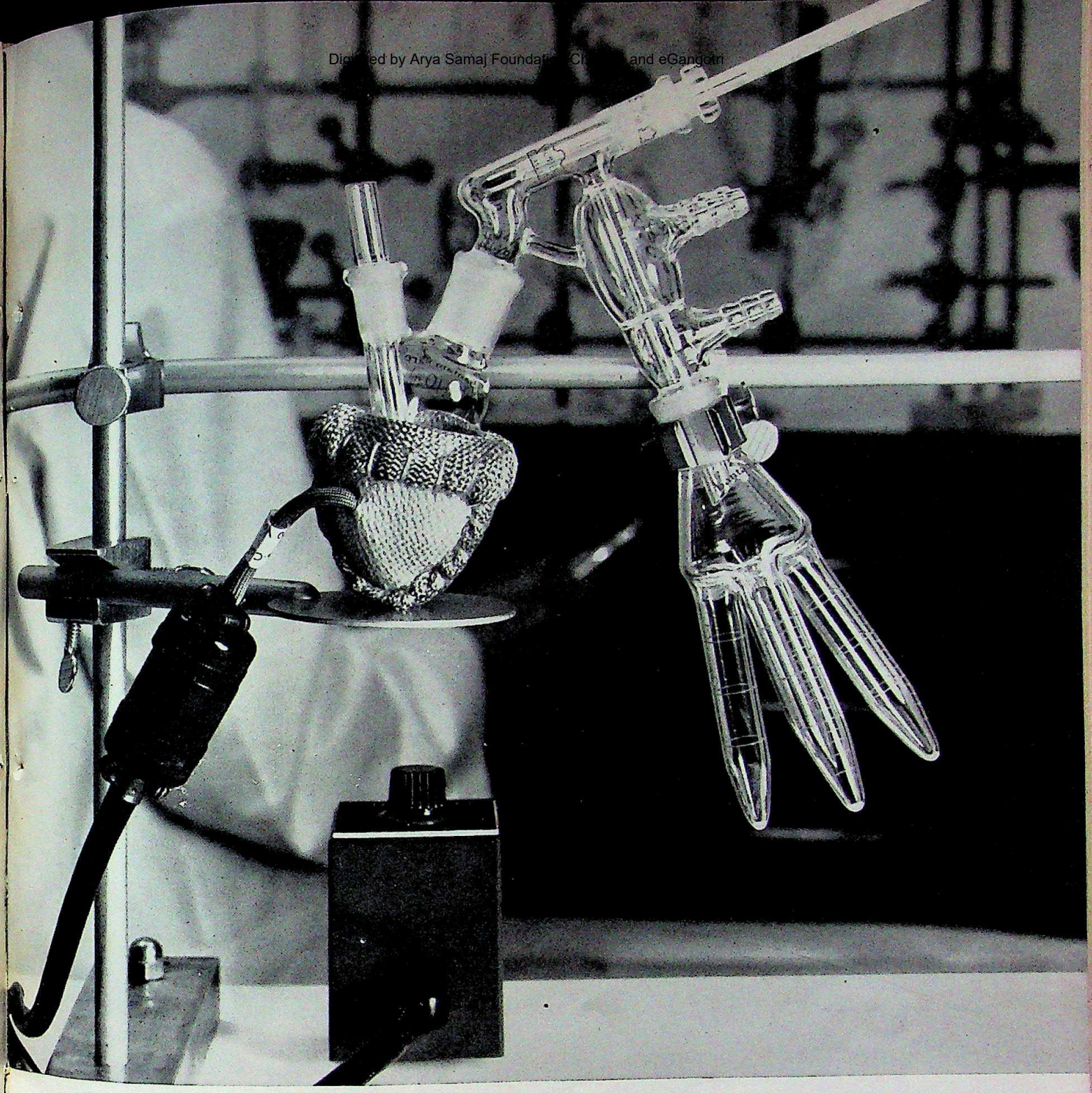

The Case of the Meandering ML's

In the vicinity of many research laboratories, small organic solutions are being mysteriously lost, daily. They are placed in small flasks, heated, and then . . . they vanish. Chemists patiently wait for their meandering ml's to show up. Sometimes a few straggle into fraction cutters, but most of them escape. The M.O. is always the same. Our job . . . find them.

Acting on a tip from Dr. Raymond Firestone at Merck & Co., Rahway, we went to work on our new K-28480 Bantam-ware Short Path Fractionator. Make the column about an inch long and let the thermometer bulb and stem serve as a packing, he said. Construct the condenser and vacuum connection in two inches, total length. Use only one joint on the fraction cutter but design it so that pipettes can be inserted to the bottom of any of the four receivers. Then, tilt the whole assembly so that drops fall from the drip tip ₮ 14/20 joint into one of the four receivers without unnecessary wetting. But nothing is vertically aligned, we pleaded. I know, he said. In desperation, we tried it.

We're happy to report that most of the meandering ml's now show up as product. The case is closed. Sequel: K-28480 has been added to the line because it fits in with the whole Bantam-ware concept. Very compact, low hold-up . . . functional.

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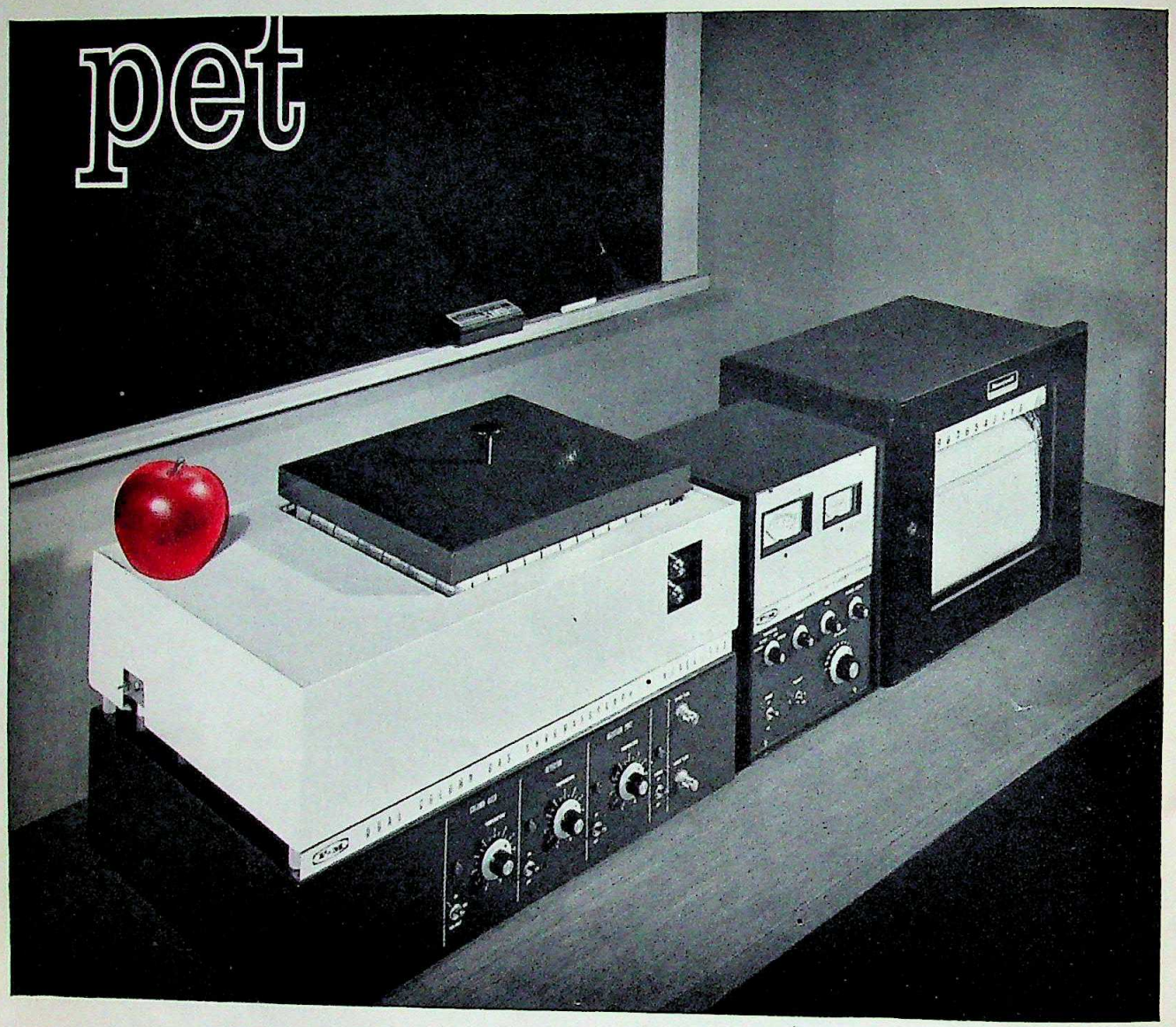
teacher's pet



A Gas Chromatograph for use as a teaching device must possess two almost opposite qualities: low cost and high performance. ▪ The $995.00 price of F & M's new Model 700-00 Gas Chromatograph clearly meets the first requirement. But this in itself is no great accomplishment: others have done it. The difference is that the Model 700-00 is a high-performance dual column thermal conductivity instrument with many features that enhance its usefulness in teaching modern techniques of instrumental analysis: high temperature operation, regulated voltage supply for oven and detector heaters, manual temperature programming, easy column and oven accessibility and a modular design to permit the addition of attachments as the need arises and the budget permits. ▪ Write for full details on the Model 700-00, a rugged instrument that takes student abuse in stride, and carries the standard F & M full-service one year warranty. F & M Scientific Corporation, Route 41 and Starr Road, Avondale, Pennsylvania, tel. 215-268-2281. European subsidiary: F & M Scientific Europa N. V., Leidsestraat 67, Amsterdam, The Netherlands.

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Chem Ed

Out of the EDITOR'S BASKET

Edited by William G. Kessel

When writing for additional information about new products or for new literature, your inquiry will receive prompt attention if you write on your firm or Institution letterhead and mention the Journal of Chemical Education and the date of the particular issue. Pamphlets, booklets and similar literature are gratis unless otherwise specified.

New Apparatus and Equipment

▶ A family of three new compact neutron generators providing high neutron yield at low cost, and designed for either steady or pulsed operation, have been introduced by SAMES (Societe Anonyme de Machines Electrostatiques) of Grenoble, France. Further details may be obtained by writing SAMES USA, Inc., 269 Commercial Ave., Palisades Park, New Jersey.

▶ The Blood Gas Accessory is a sample conditioner used in combination with the Beckman GC-2A Gas Chromatograph. Instrument performance will permit a 4-min., standard run analysis of oxygen, nitrogen, carbon monoxide, and carbon dioxide in a blood sample. Write the Technical Information Section, Beckman Scientific and Process Instruments Div., 2500 Harbor Blvd., Fullerton, California for *Bulletin 7019*.

▶ Westronics, Inc., 3605 McCart St., Fort Worth 10, Texas, announces the availability of their new laboratory strip chart recorder Model LS11A, which was designed exclusively for laboratory and basic research personnel. Ask for *Data Sheet 273*.

▶ A unique deal survey instrument for practically the cost of a standard alpha or neutron device is announced by Physics International, 2229 Fourth St., Berkeley 10, California. The PI Master Survey Instrument normally functions as a large area alpha instrument, but also features a directly interchangeable probe that functions as either a thermal or fast neutron detector.

▶ To permit the rapid and reproducible analysis of pyrolysis products by gas chromatography, F & M Scientific Corp. of Avondale, Pennsylvania has introduced a new dual probe pyrolysis unit, the Model 80. The device permits the pyrolysis of non-volatile substances containing traces of organic materials, directly in the injection port of the gas chromatograph.

▶ Prepkromatic, a unique advance in gas chromatographic instrumentation has been announced by Nester/Faust Mfg. Corp., 2401 Ogletown Rd., Newark, Delaware. This versatile instrument provides rapid, automatic injection, separation and collection of pure chromatographic fractions on a repetitive basis.

▶ Sturdilite Products, Inc., 3001 Palmolive Bldg., Chicago 11, Illinois, announces a copper shielded laminated counter top for use in areas where shielding or radio frequency interference problems are present.

▶ The RS5-2 salinometer just announced by Industrial Instruments, 89 Commerce Rd., Cedar Grove, New Jersey, features an inductive cell that operates without electrodes and eliminates all electrode maintenance problems. The instrument provides direct linear readout and permits salinity, temperature and conductivity measurements to be made to depths of 400 feet by simply lowering the electrodeless cell.

▶ Bel-Art Products, Pequannock, New Jersey, offers heavy walled polyethylene trays with welded construction that are rigid, tough, unbreakable and impervious to strong acids, alkalies, and some solvents.

▶ Scientific Products, 1210 Leon Place, Evanston, Illinois, offers a completely disposable sterile polyethylene bag for transporting or storing liquid or solid samples. Pull-tab opening eliminates contamination from fingers.

(*Continued on page A803*)

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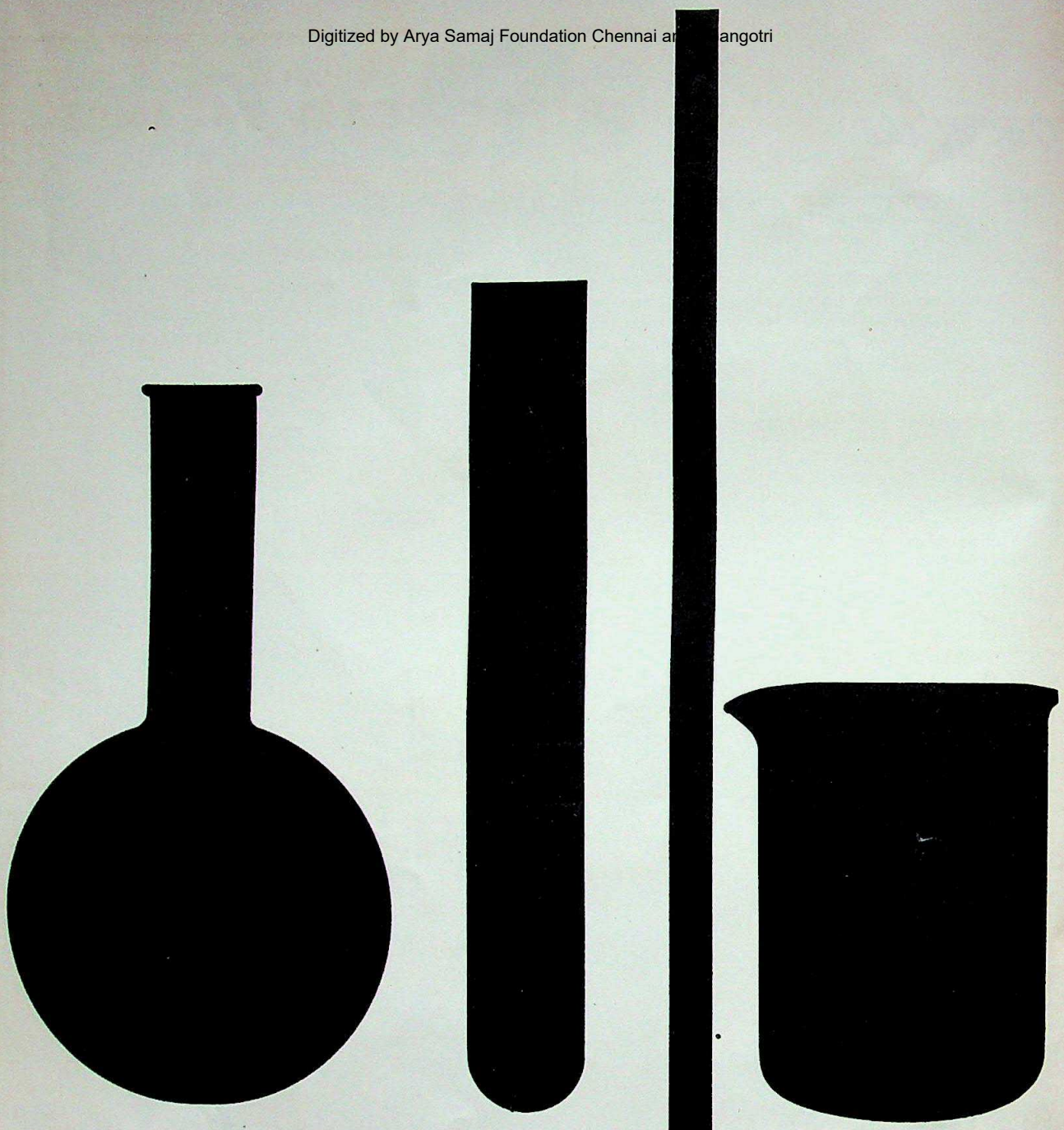

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Out of the EDITOR'S BASKET

▸ The Reichert "Visopan," a complete micro-projector combining a microscope, an illuminating system, and a projection screen into one compact unit, can now also be equipped for photomicrography with 4 × 5 inch Graflok back and for application of the standard Polaroid Land Camera back. For complete particulars write to: William J. Hacker & Co., Inc., P.O. Box 646, West Caldwell, New Jersey.

▸ Economical time and count print-out for automatic sample changer systems is offered by Nuclear-Chicago's new Series 8700 instruments. They combine a fast decade scaler, an electronic timer, regulated high voltage supply, and sample changer programming facilities in a single, compact model. Solid state circuitry is used throughout. For complete specifications write to Nuclear-Chicago Corp., 359 E. Howard Ave., Des Plaines, Illinois.

▸ Telewave Laboratories, Inc., 43-20 34th St., Long Island City 1, New York, introduces a variable speed chopper for infrared, ultraviolet, and visible light. It lends itself for use in prototype development, test instruments, transmitter and receiving systems, and general-purpose laboratory applications.

▸ A new nuclear counting system, the Multi/Matic MM560, for rapid, accurate analysis of radioactive materials has been introduced by Tracerlab, 1601 Trapelo Rd., Waltham 54, Massachusetts. The Multi/Matic MM560 counting system uses interchangeable detector heads for assay of solid samples in which alpha, beta, or gamma radiation may be present in varying amounts.

▸ Plugs of "Teflon" TFE provide vacuum-tight seals yet smooth-gliding action in three new plastic stopcocks developed for laboratory use by The Nalge Co., Inc., 75 Panorama Creek Drive, Rochester 25, New York.

▸ New plastic coated round bottom flask rings that abolish the need for old fashioned cork rings has been introduced by Penn-Chemical Corp., 232-38 N. Marshall St., Lancaster, Pennsylvania.

▸ The Gyra Model E-307 Electrometer for improved performance, accurate zero, greater stability and faster response, is offered by Gyra Electronics Corp., P.O. Box 184, La Grange, Illinois.

▸ Scientific Glass Apparatus Co., Inc., Bloomfield, New Jersey, announces the development of a new manometer originally designed for use by students in introductory organic chemistry, but which is also suitable for measuring pressures in the 0–140 mm range in any laboratory.

▸ Recognizing a need for an increased degree of precision in measuring the vis-

(*Continued on page A804*)

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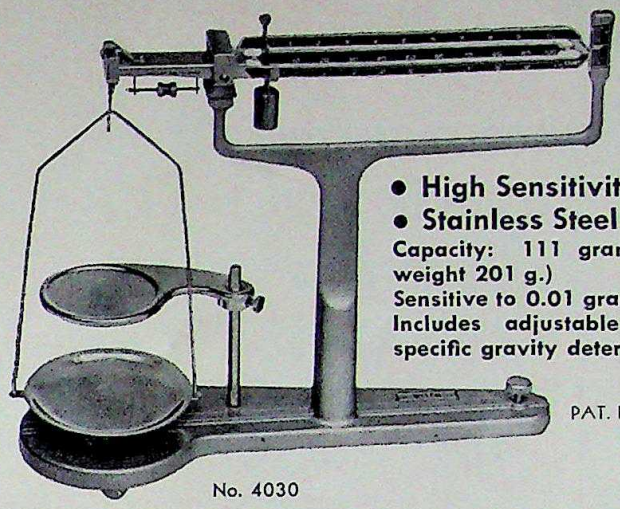

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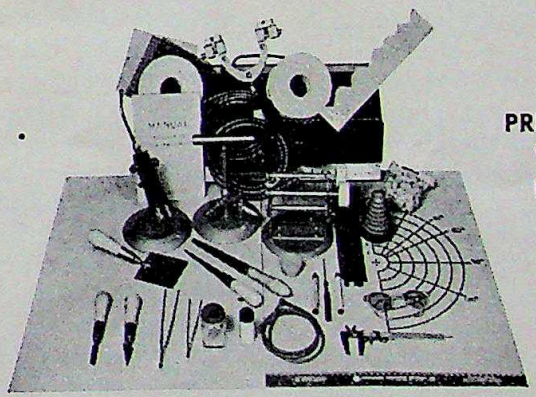

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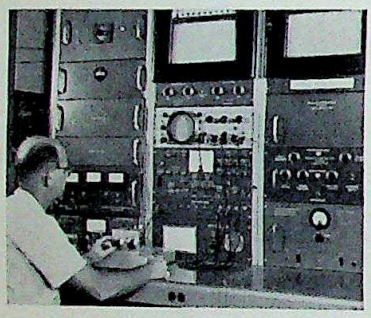

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In Canada, write Bausch & Lomb Optical Co., Ltd., Dept. 661, Scientific Instrument Division, 16 Grosvenor Street, Toronto 5, Canada.

cosity of fluids, Ferranti Electric, Inc., Industrial Park No. 1, Plainview, Long Island, New York, made available a new electronic viscometer a few years ago. The company now announces that four distinct improvements have been made in the viscometer, which analyzes fluid substances by placing a small sample between a rotating metal cone and a stationary flat plate.

▶ Barnstead Still and Sterilizer Co., Lanesville Terrace, Boston 31, Massachusetts, reports that its steam heated still with new feedback purifier eliminates water Still cleaning, provides distilled water of higher purity, and now incorporates two new features which insure efficiency of operation.

▶ Instrument and Communications, Inc., 33 Danbury Rd., Wilton, Connecticut, offer a new, inexpensive, all solid state, recorder accessory which provides 10:1 gain in sensitivity for any potentiometric recorder. It is called the Variable Recorder Amplifier.

▶ A new X-Band electron paramagnetic resonance spectrometer of extreme sensitivity is now available from Alpha Scientific Laboratories, P.O. Box 333, Berkeley, California. This unit is an addition to the standard 340 megacycle and 30 to 60 megacycle EPR units which have been available.

▶ A new portable electrophoretic instrument capable of quantitative and qualitative biomedical, chemical, and pharmaceutical analyses often unavailable through other techniques has been announced by Perkin-Elmer Corp., Norwalk, Connecticut. Designated the Model 238 Tiselius electrophoresis apparatus, the instrument uses a method widely applicable to analysis of protein mixtures and fractional purifications.

▶ Scientific Machine & Supply Co. of Middlesex, New Jersey has developed an adjustable thermometer seal that eliminates the need for multi-laboratory equipment. The new seal will fit any laboratory flask and utilizes any conventional thermometer.

▶ A new recording spectropolarimeter, designed for the precise, automatic recording of optical rotatory dispersion over the wave-length range from below 1900–6000 Å is being introduced by Applied Physics Corp., 2724 S. Peck Rd., Monrovia, California.

▶ Both automatic printed readout and variable function conversion, features usually associated only with much larger and more expensive computers, are performed by Datascribe, a new bench-top size, analog to digital converter now being produced by Research Specialties Co., 200 S. Garrard Blvd., Richmond, California, for general laboratory use.

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Out of the EDITOR'S BASKET

▸ Designed to produce intense homogeneous fields over a large volume, Alpha's new aluminum strip wound solenoid coils provide an efficient magnetic field suitable for many requirements. This solenoid is one of a standard series of solenoid coils produced by Alpha, which are capable of providing fields up to 20 kilogauss. For details write Alpha Scientific Labs., P.O. Box 333, Berkeley 1, California.

▸ The labware industry's first plastic separatory funnel is announced by The Nalge Co., Inc., 75 Panorama Creek Dr., Rochester 25, New York. Available in a 500 ml. Squibb pear shape design, the new Nalgene® separatory funnel is molded of unbreakable polypropylene featuring unusual clarity.

New Literature

● A new brochure describing four models of explosion-proof refrigerators and freezers is now available from Kelmore, Inc., 599 Springfield Ave., Newark 3, New Jersey.

● The Amersil Quartz Div. of Engelhard Industries, Inc., 75 Austin St., Newark 14, New Jersey, has published a new *Data File* on quartz glass bi-distillation apparatus. The bi-distillation apparatus described prepares water of 0.55 to 0.9 $\times$ 10^{-6} (Siemens/cm) in a single operation as two distillation stages are incorporated in a single closed system.

● The Model 154D vapor fractometer, basic instrument in the Perkin-Elmer gas chromatography line, is described in a new 12-page brochure. Designed for industrial or research analyses, the Model 154 D features the latest advances in gas chromatographic sampling, separation and detection techniques. Copies of the booklet are available on request from Instrument Div., Perkin-Elmer Corp., Main Ave., Norwalk, Connecticut.

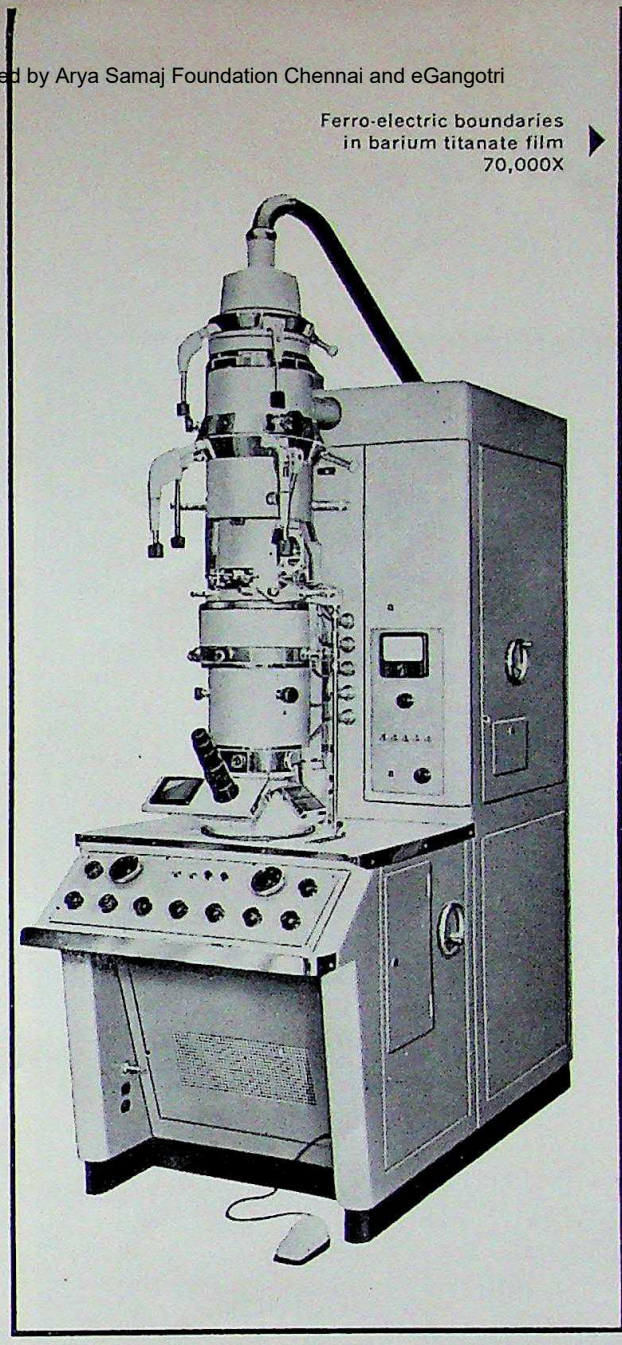
● Copies of a new laboratory hardware brochure are available from Central Scientific Co., 1700 W. Irving Park Road, Chicago 13, Illinois.

● A descriptive flyer and sample of Carter Products Co.'s flexible rubber magnet may be obtained from Carter Products Co., P.O. Box 1924, Columbus 16, Ohio.

● A new brochure is available on safety pipetters describing "Clinac" mechanical pipetters in micro and standard sizes and the "Pumpett" automatic pipette control from La Pine Scientific Co., 6001 S. Knox Ave., Chicago 29, Illinois.

● Cahn Instrument Co., 15505 Minnesota Ave., Paramount, California offers new descriptive literature on the "*Cahn R. G. Electro-balance.*"

(*Continued on page A806*)



Ferro-electric boundaries in barium titanate film 70,000X ▸

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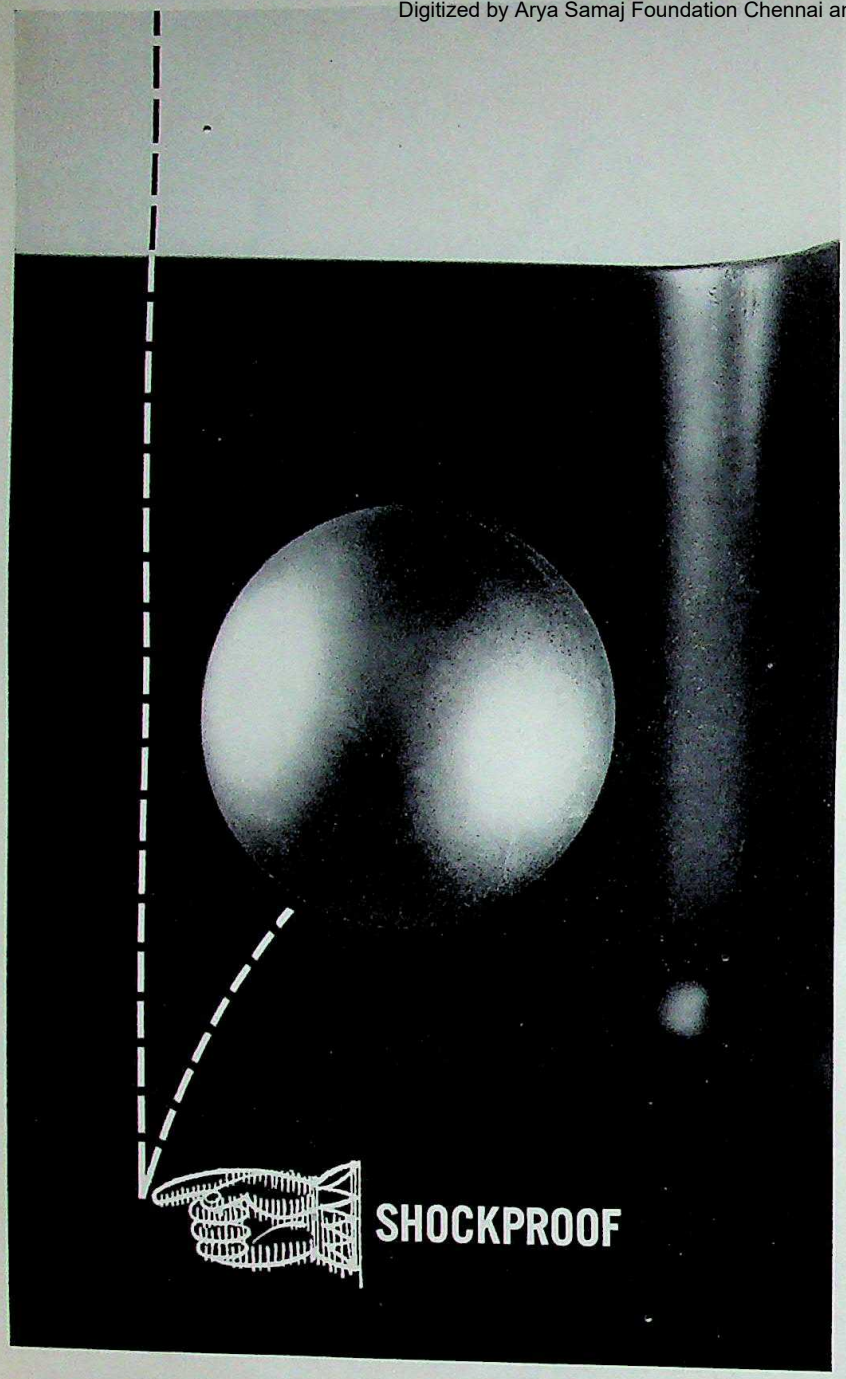

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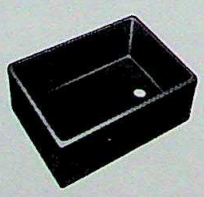

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Out of the EDITOR'S BASKET

● "There Was a Time," a reprint of a story from *The Diamond Story* describing the world without modern chemicals is available from Harry P. Wiseman, Diamond Alkali Co., Cleveland 14, Ohio.

● Description of an instrument, the DSC-1 using an entirely new principle of thermal analysis is provided in a new booklet from Perkin-Elmer Corp., Main Ave., Norwalk, Connecticut. The new instrument, the Differential Scanning Calorimeter, is described as making possible for the first time the direct measurement of heats of reaction and transition, using micro samples, in a fraction of the time required with conventional equipment.

● Gow-Mac chromatography detectors and katharometers—including hot-wire, thermistors and micro-cells—are described in new six page bulletin *TCTH*. Please request copies from the Gow-Mac Instrument Co., 100 Kings Rd., Madison, New Jersey.

● Single copies of *Power from Isotopes* are available from U.S. Atomic Energy Commission Division of Technical Information Extension, Educational Materials Section, P.O. Box 62, Oak Ridge, Tennessee.

● New bulletin on *"Tecam" Micro-Tensile Testing Machine* just published by LaPine Scientific Co., 6001 S. Knox Ave., Chicago 29, Illinois describes optical and mechanical operation of instrument developed for tensile testing of single crystal "whiskers." Instrument is also used for testing fibers and thin films, as well as specimens in compression.

● Corning Glass Works, Corning, New York has three new booklets available to make the ordering, fabricating, and installing of Pyrex brand drainline easier; a catalogue of drainline fittings *BP-400*, "How to Install," *BP-410*, and *BP-411* methods of cutting and beading glass drainline.

● Copies of *Technical Bulletin*, Volume IV:No. 1, may be obtained from the Technical Service Dept., Engelhard Industries, Inc., 75 Austin St., Newark 14, New Jersey. The issue includes articles entitled "Stereochemistry of Hydrogenation of Toluidines and Methycyclohexanone Oximes with Rhodium and Ruthenium Catalysts," and "A Review of Recent Work with the Platinel Thermocouple."

● A new Bulletin, *SA-1*, featering the "Spectrographic Analyzer," a complete low-cost spectrographic laboratory, has just been published by Applied Research Laboratories, Inc., P.O. Box 1710, Glendale 5, California.

(*Continued on page A808*)

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FILTRATION CHART

for use in chemical analysis

relative retention values

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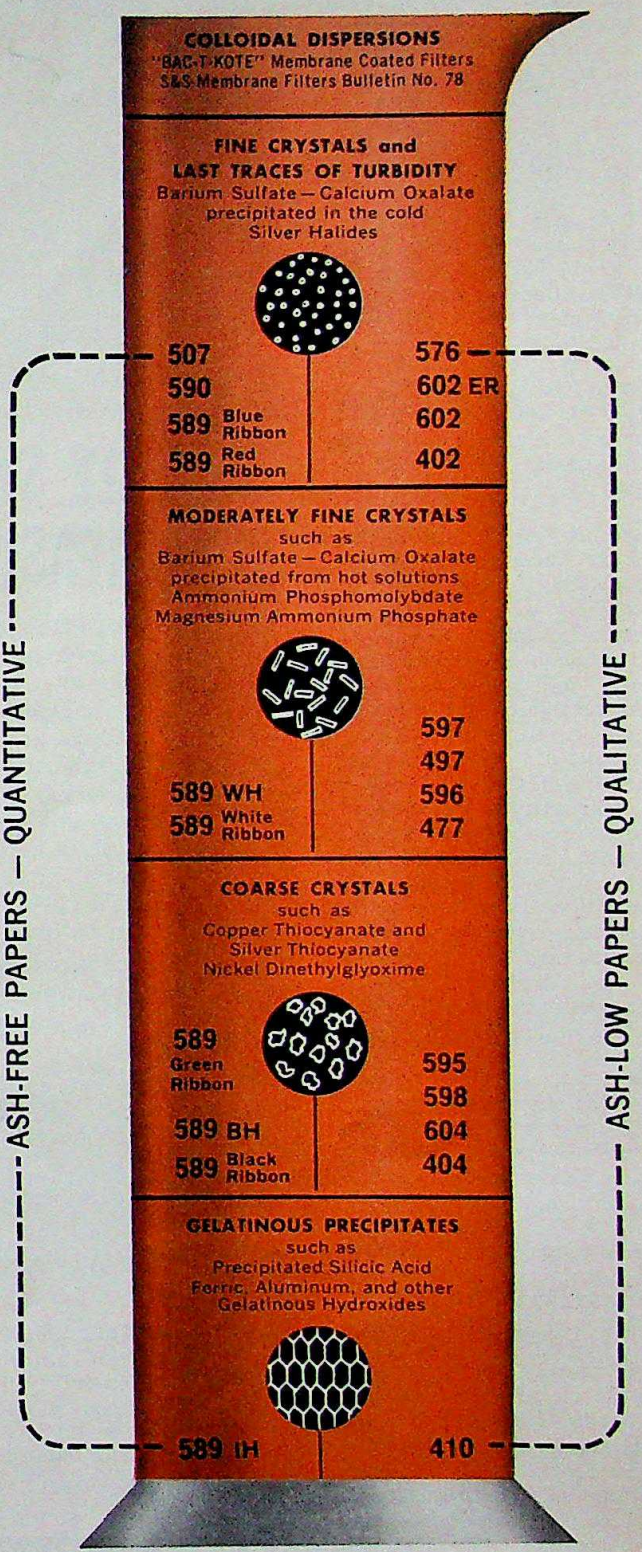

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Out of the EDITOR'S BASKET

● To introduce its new KY-2 flame photometer, Baird-Atomic, 33 University Rd., Cambridge 38, Massachusetts, has just published an eight-page brochure. The KY-2 features an exclusive design which permits the combined versatility of either clinical or research analysis of sodium and potassium from a single sample. The brochure constitutes a manual on the principles of flame photometry, but also describes the advantages of the new Baird instrument.

● *Bulletin WB-1* describes the Sargent thermonitor controlled constant temperature bath. It has just been published by the designer and manufacturer, E. H. Sargent & Co., 4647 W. Foster Ave., Chicago 30, Illinois.

● A four page brochure describing the new low cost HR-96, $8^1/_2 \times 11$ inch X-Y recorder is now available. Write Houston Instrument Corp., 4950 Terminal Ave., Bellaire 101, Texas for a copy.

● Cole-Parmer Instrument and Equipment Company's 1963–64 catalogue—a detailed reference book for the chemist, engineer, biologist, and related user of scientific equipment—now is off the press. The volume is a comprehensive compilation of up-to-date instruments and equipment for general research, clinical study, production, quality control and pilot plant operation.

Besides the more basic requirements of the scientist sub-divisions of the catalogue deal with thermistor-based instrumentation, chemically-resistant liquid transfer, metering and vacuum pumps, precision temperature control and heat-treating equipment, and clinical instrumentation.

For a free copy, write to Cole-Parmer Instrument & Equipment Co., 7330 N. Clark St., Chicago 26, Illinois.

● A new and highly versatile instrument for the research biochemist, the Beckman Spectrochrom* Analyzer, is described in a brochure just published by Spinco Div. of Beckman Instruments, Inc., Palo Alto, California.

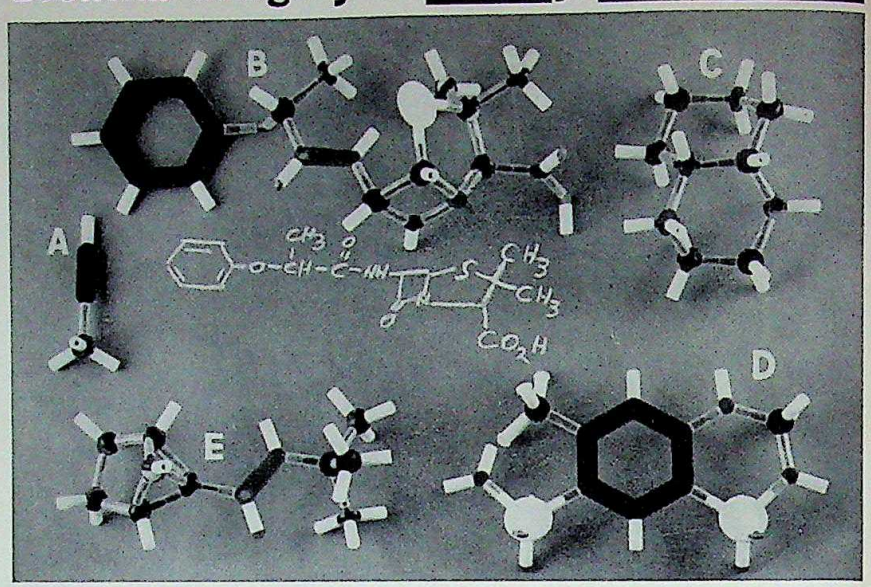
● A new, enlarged edition of the *MC & B Laboratory Chemical Catalogue* has been released by the MC & B Division of The Matheson Co., Inc., P.O. Box 85, East Rutherford, New Jersey.

● Copies of *About Gases* are available from the National Fire Protection Association, 60 Batterymarch St., Boston 10, Massachusetts. It contains a complete listing of the Association's standards, informative manuals, technical pamphlets, posters and other materials concerned with the safe storage, handling, and use of gases.

● Over 200 essential laboratory and pilot plant items for mineral and chemical

(*Continued on page A810*)

Bronwill brings you Godfrey Stereomodels



Can you match these Stereomodels with their correct names? See bottom of page.

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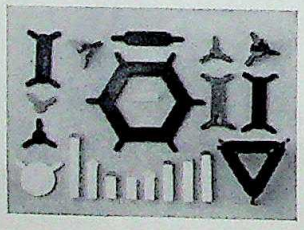

STEREOMODELS IN TOP PHOTO: A. Methylacetylene; B. α Phenoxyethyl Penicillin; C. *cis* Decalin; D. Bicyclo [2,1,1,$0^{5,6}$] hexane-5 (N-t-butyl) carboxamide; E. 6-Trifluoromethyl -7-sulfamyl-3,4-dihydro-1,2,4-benzothiadiazine 1,1-dioxide.

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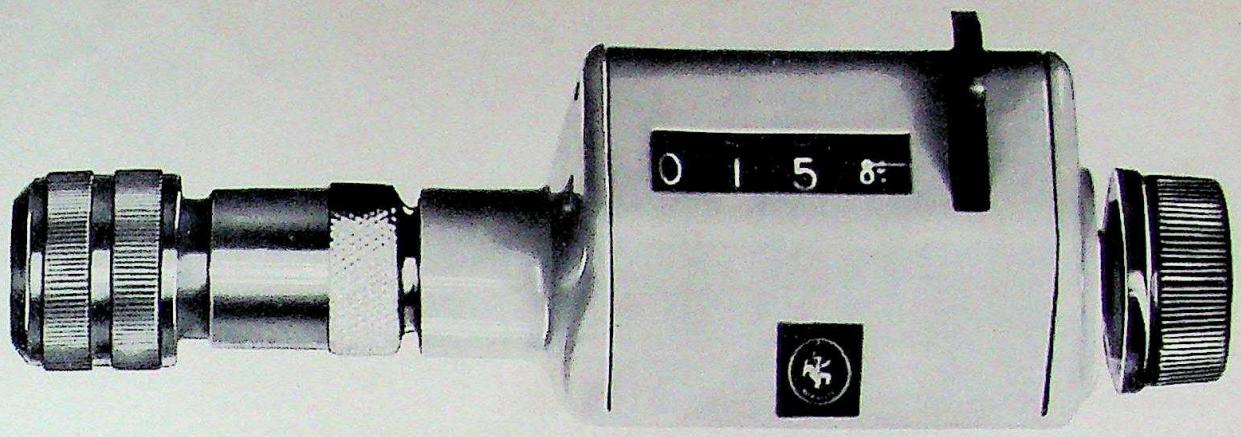

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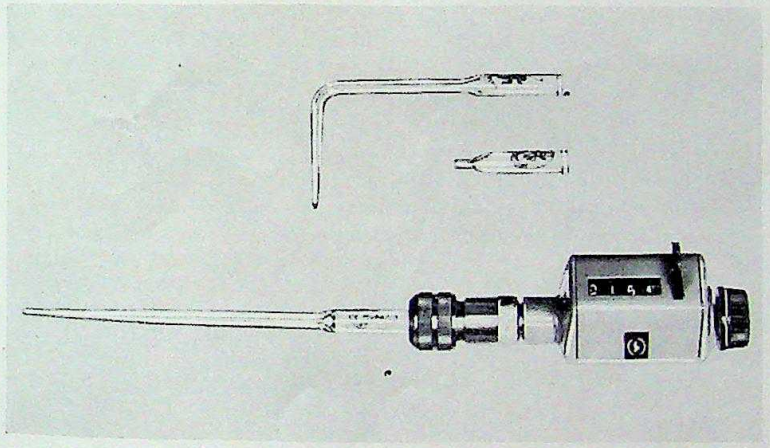

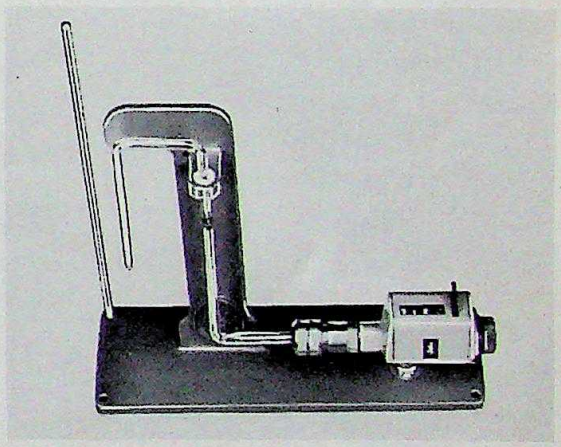

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processing laboratories are illustrated in a new 68 page catalogue, *LG3-Blt.* Write for a copy to the Denver Equipment Co., 1400 17th St., Denver 17, Colorado.

● The Lab-Crest Scientific Div. of Fischer & Porter Co., 574 Jacksonville Rd., Warminster, Pennsylvania, announces the publication of a new complete price book on its line of laboratory equipment and glassware.

● *Union Carbide's Research and Development Capabilities* are described in a new folder. Copies may be obtained by writing to Department 43, Union Carbide Corp., 270 Park Ave., New York 17, N. Y.

● The Edmund Scientific Company's new catalogue *No. 635,* featuring thousands of unusual and hard-to get industrial and scientific items, is now available free on request. Write Edmund Scientific Co., Barrington, New Jersey for a copy.

New Chemicals

◇ W. H. Curtin & Co., P.O. Box 1546, Houston 1, Texas introduced a new aid for gas chromatographers, a series of inexpensive packing kits for GC columns. These helpful kits will assist the laboratory worker to quickly determine which chromatographic column best suits their individual requirements.

◇ Three new radiochemicals for use as chromatography standards or in atherosclerosis nutritional and fat metabolism studies are immediately available in liquid form from Tracerlab, 1601 Trapelo Road, Waltham 54, Massachusetts. Methyl Linoleate-1-C^{14} (*Catalogue L4-86*), Methyl Oleate-1-C^{14} (*Catalogue L4.84*), and Methyl Stearate—1-C^{14} (*Catalogue L4-83*) are also available.

Miscellany

★ Bell Telephone Laboratories has announced the availability of two new college science films, one in the field of physics and the other in physical chemistry. The films entitled "Principles of the Optical Maser" and "Physical Chemistry of Polymers," were prepared at Bell Laboratories under the direction of scientists who are acknowledged authorities in their fields. Both films are available on free loan from local Bell Telephone business offices throughout the country.

★ The story of the Muller Field Ion Microscope, with which scientists are able to observe the atomic structure of matter for the first time, is told in a new 16mm film just released by Cenco Educational Films. Entitled "Eye for Tomorrow," the 15-min black and white production traces the development of the Field Ion Microscope from its conception by Dr. Erwin Muller, of the Pennsylvania State University, until it became a working instrument available to the world's scientists just a year ago. With a possible magnification of over 3,000,000 times and a resolution of better than three Angstroms, the Field Ion Microscope promises to be one of the most significant scientific instrument development of this decade. For further information regarding the film "Eye for Tomorrow," write for Booklet 509 from Cenco Educational Films, a division of Cenco Instruments Corp., 1700 Irving Park Rd., Chicago 13, Illinois.

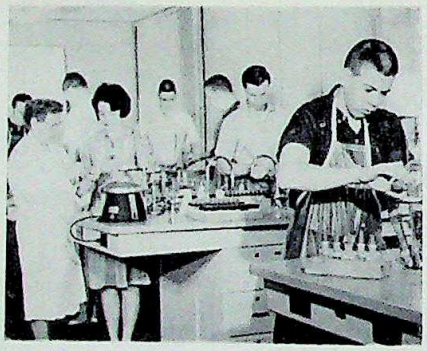
★ The 1963 Eastern Analytical Symposium will be held at the Statler Hilton Hotel in New York City on November 13, 14, and 15, 1963. The purpose of this announcement is to present the program of the meeting which is being sponsored by the Analytical Groups (ACS) of the New York and North Jersey Section, four sections of the Society for Applied Spectroscopy (New York, Delaware Valley, New England, and Baltimore-Washington), and the American Microchemical Society.

The meeting will consist of a series of 3-hr symposia of invited papers of extended length by experts in a number of fields of interest to instrumental analysts, chemists, and spectroscopists. The emphasis will be on recent developments in these specialties. The exhibition will consist of 90 manufacturers of scientific apparatus and supplies. Contact the General Chairman—J. F. Cosgrove, General Telephone & Electronics Labs or Program Chairman—H. C. Mattraw, Sperry Rand Research Center for details.

Semi-Micro Chemistry

New Film Shows Better Way To Teach High School Laboratory Chemistry

Sound slidefilm points up learning, teaching and economic advantages of miniature system

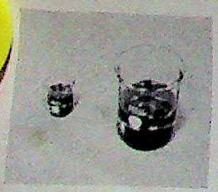


CHICAGO: The inherent advantages of the semi-micro method of laboratory chemistry are depicted in a new slidefilm, full color with sound, sponsored by Wilkens-Anderson Company, Chicago.

The film, shot in actual high school chemistry classes, discusses semi-micro from three viewpoints: the student's, the teacher's and the school administrator's.

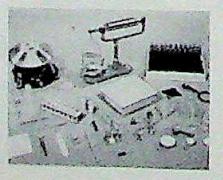
Compares Semi-Micro and Macro

In order to more vividly portray the benefits of the semi-micro method, a dramatic classroom comparison with macro is used. The film does not dwell on the comparison alone, but moves quickly on to such student and teacher advantages as more experiments, accuracy, safety and greater individual attention.



Easy Conversion Stressed

In depicting the economic advantages of semi-micro, special attention is devoted to the ease of conversion and the fact that NO capital expenditure need be appropriated. Cost comparisons, savings on replacement costs and other features, of interest to both teacher and administrator, are discussed.



The filmstrip, priced at $14.95, is available on FREE loan to all science department heads, teachers and school board members. Write, stating school and position, to Wilkens-Anderson Co., 4525 West Division St., Chicago, Illinois.

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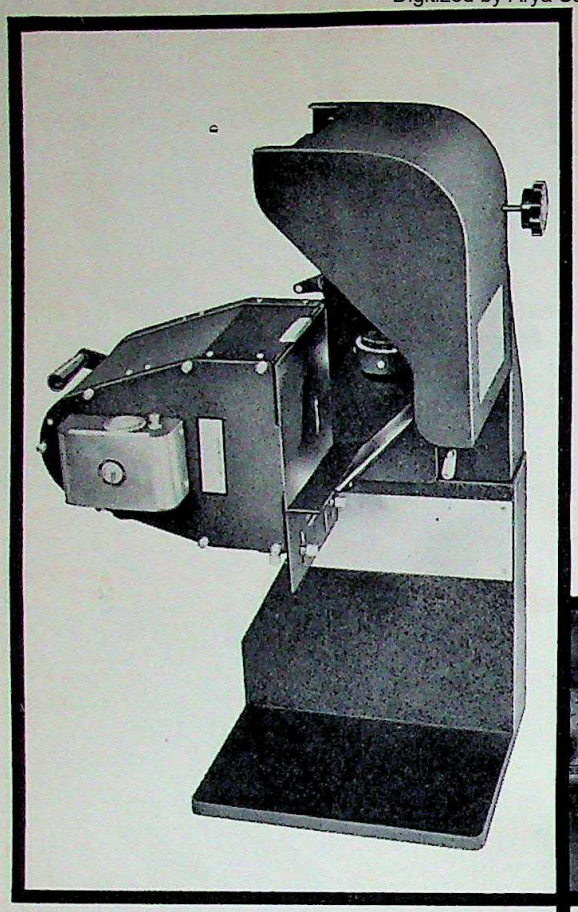

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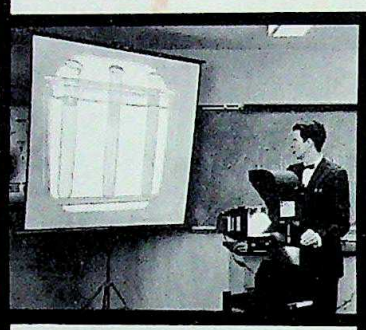

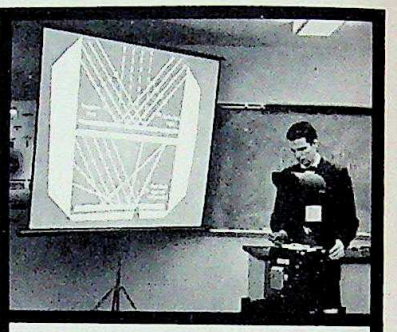

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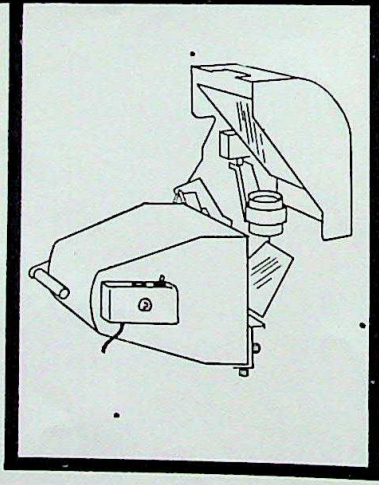

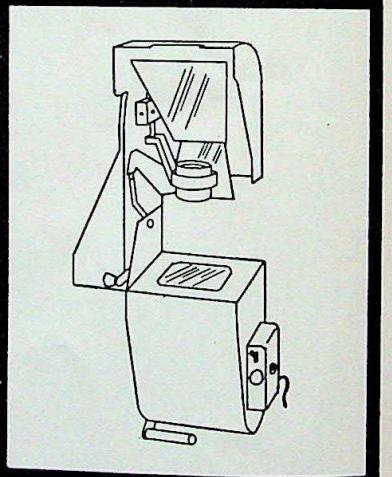

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Princeton University

Note: Figure SD-18 Cryophorus for Dem. 88 in the September issue appears on the next page.

2. PHYSICAL PROPERTIES OF WATER (Continued)

Humidity

Dem. 95—Humidity Indicator

To show: Moisture is in the air, evidenced by the color change of a cobalt salt.

Materials: 5 × 1-in. strip of clear photographic film (or clear plastic film dipped into a thick gelatin solution and dried), $CoCl_2$, isopropyl alcohol, cell C-2.

Preparation: Soak the plastic strip in conc. $CoCl_2$-aq. Heat gently to dry to a blue color. Store dry in a stoppered bottle.

Procedure: (*a*) Lower the blue strip into the chambers of C-2 in (1) dry air, or isopropyl alcohol and (2) water. (*b*) Hold a strip tightly in the palm of the hand, or breathe on the strip. Project.

Observations: (*a*) the $CoCl_2$ turns pink in water, blue in dry air or isopropyl alcohol. (*b*) Moisture from the hand or breath colors the blue strip pink; even the fingerprints can be seen projected.

Note: At this point show the class a "weather tell-tale" available in gift shops, usually a card with cloth colored by $CoCl_2$ which turns blue for fair (dry) weather and pink for rainy (wet) weather. Also show Drierite or silica gel desiccant which has been treated with $CoCl_2$ to show whether the absorbent is fresh (blue) or spent and unsuitable (pink).

Dem. 96—Wet-Dry Bulb Thermometer

To show: Relative humidity by contrasting the temperatures of wet and dry bulbs, the principle of a psychrometer.

Materials: Two 1-oz. square dropping bottles with rubber bulbs, 2 mm capillary tubing 6-in. long, food coloring, a piece of cloth about 4 × 1½ inches, rubber band.

Preparation: Cut the rubber stoppers half-off, and through them lead the capillary tubing bent into an inverted U-tube 3-in. long. Wrap one of the bottles in cloth and secure with the rubber band.

Procedure: Immerse both bottles in a trough of water for several minutes. Remove, wipe the unwrapped bottle dry. Place a drop of colored water in the capillary U-tube in the arm which will lead into the unwrapped bottle. Insert the U-tube in the bottles. Project.

Observation: Within a minute the cooling effect of the evaporation of water from the wet cloth will cause the colored liquid to move toward that bottle. (Noerdin)

Dem. 97—Bobby-Bird

To show: Evaporation of water causes contraction of air, and makes the Bobby-bird duck his head.

Materials: An all-glass Bobby-bird, available in some gift shops, the bird who continually bobs down his beak into a pan of water; plastic frame for the bird.

Preparation: See SD-19. The paint and feathers must be dissolved off the glass bird, acetone being a good solvent. Leave the cloth material on the bird's head. Make a base as shown in Figure SD-19, and pivot the bird so that he is just barely upright. A block at his head helps adjust him properly.

Procedure: Pour water over his head. Project. In a few minutes he will begin to duck down, then swing upright, repeating the cycle at minute intervals for some quarter of an hour.

Notes: 1. Explain how evaporation of water from the cloth head cools down the air inside the head; this creates a partial vacuum, and the liquid inside of the inner straight tube can be seen on the projector being sucked up toward the head. When sufficient liquid has reached the forward portion of the bird, the center of gravity has shifted sufficiently for the bird to duck downwards.

2. Call attention on the screen how the liquid in the head of the bird flows along the inner tube, and air from the tail transfers to the head during the return-to-upright movement.

3. It is unnecessary to have the head dip into a pool of water. Sufficient water can be placed on the head in one dunking to make the bird operate for many minutes. Of course if it ducks its head into a tank of water the process will continue indefinitely.

Aqueous Tension (Vapor Pressure of Water)

Dem. 98—Desiccation of Moist Air

To show: The drop in vapor pressure of water vapor in the presence of a desiccant.

Materials: Test tube connected via rubber tubing to a mercury-filled Mp-760 manometer; Drierite.

Procedure: Fill the test tube with *moist* air (breath), and connect to Mp-manometer. Project. Drop in a quarter tube-full of Drierite or other solid desiccant.

Observation: The pressure drops steadily as the water vapor is absorbed by the desiccant. (Ulery)

Dem. 99—Vapor Pressure of H_2O at Room Temperature

To show: A comparison of the vacuum achieved with an oil pump versus a water aspirator.

Materials: Oil pump, water aspirator, Mp-o with valve and 6 mm tube with serum cap in stopper, 2 ml hypodermic syringe.

Procedure: (*a*) Clean, and dry Mp-o thoroughly (this is important). Evacuate it, and shut valve. Project. Record level (or differences in levels) in the J-o manometer. Inject 0.5 ml H_2O. Record the new heights.

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(*b*) Fill the Mp-box half full of water, evacuate with (*1*) oil pump, (*2*) water aspirator. At the end of the latter operation admit air before turning off aspirator to avoid flooding Mp-o with water. Read new J-tube levels.

Observations: (*a*) The change in pressure is about 28 mm at room temperature of about 28°C. (*b*) The oil pump gives a near-zero reading; a good water aspirator gives a reading about 28 mm higher, corresponding to the vapor pressure of water at 28° C. (Ulery)

Dem. 100—Vapor Pressure of H_2O at Different Temperatures

To show: The change in vapor pressure of water as temperature is changed.

Materials: Mp-J-tube assembly, 5 × $1^3/_4$-in. transparent plastic trough, 2 ml syringe, 18 × 70 mm test tube with 2-hole stopper, 1-in. length of 6 mm tubing with rubber serum cap, fish-valve, 0–100°C. thermometer, vacuum source.

Preparation: Bore hole in base of valve and solder in it a $^1/_2$-in. length of $^1/_8$-in. brass tubing. In the 2-hole stopper insert this valve and also the 6 mm tubing with serum cap. Connect to J-tube assembly.

Procedure: Evacuate test tube-J-tube assembly, shut valve, remove from vacuum pump, and place in plastic trough on projector. Record pressure and temperature readings for (*a*) tube empty at room temperature, (*b*) tube with 2 ml of H_2O injected at room temperature, (*c*) ditto, with 2 ml more of H_2O injected, (*d*) with 4 ml H_2O and with entire assembly immersed in trough of ice-water, and (*e*) ditto, in water at 30 to 50°C.

Observation: Vapor pressures of H_2O at 1°, 26.2°, and 47.0°C. were 5.0, 28, and 79 mm respectively, within 5% of theoretical. (Ulery)

Dem. 101—Deliquescence

To show: The deliquescence of NaOH and $CaCl_2$.

Material: NaOH pellets, 4-mesh $CaCl_2$, microscope slides, horizontal projector or cell Ho.

Procedure: Place a NaOH pellet at one end of a microscope slide, and a lump of 4-mesh $CaCl_2$ at the other. Project for 15 min on a horizontal stage.

Observation: Puddles of solution form as the substances deliquesce. (Rolf)

Dem. 102—Deliquescence of $MgCl_2$

To show: The slow deliquescence of $MgCl_2$.

Materials: $MgCl_2$, test tube or vial fitting inside of Mp-o.

Proceedings: Half-fill the glass vial with a saturated solution of $MgCl_2$, or solid $MgCl_2$, and set in Mp-O quarter-full of water. Evacuate and shut the valve. Let stand. Project from day to day.

Observations: Water passes over into the tube containing the $MgCl_2$ as it deliquesces. The level of water rises in the $MgCl_2$ tube and falls in the outer Mp box over the following days.

Notes: 1. Mark the water level each week for a month.
2. A plastic inverted U-tube with saturated $MgCl_2$ in one limb and water in the other can be used. Or, a flat cell with two limbs connected by a passage-way. Hang up out-of-reach of the pupils so that it can be observed from day to day, but not disturbed or tilted.

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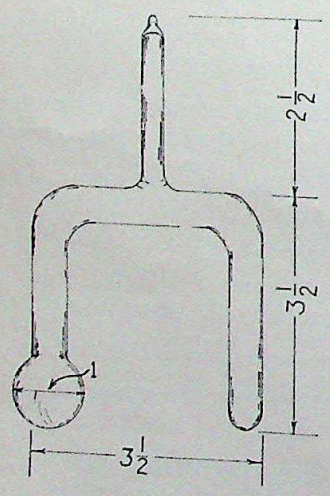
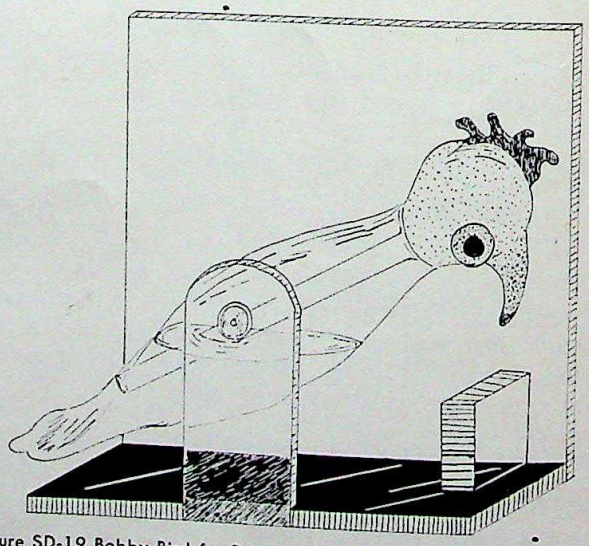


Figure SD-18 Cryophorus



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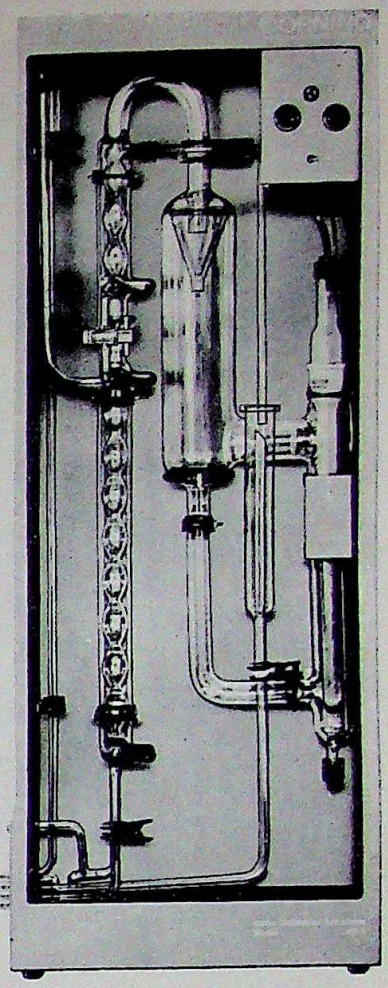

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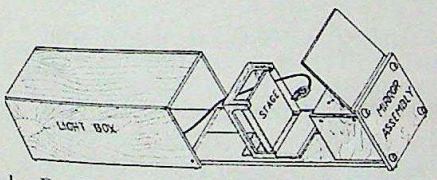

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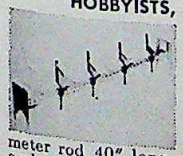

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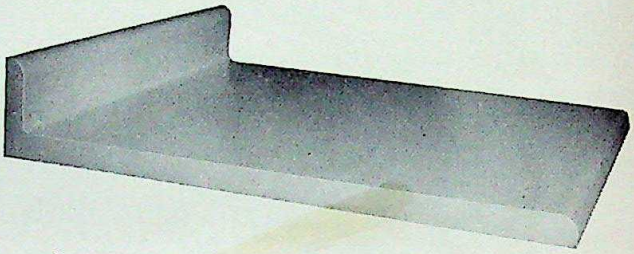

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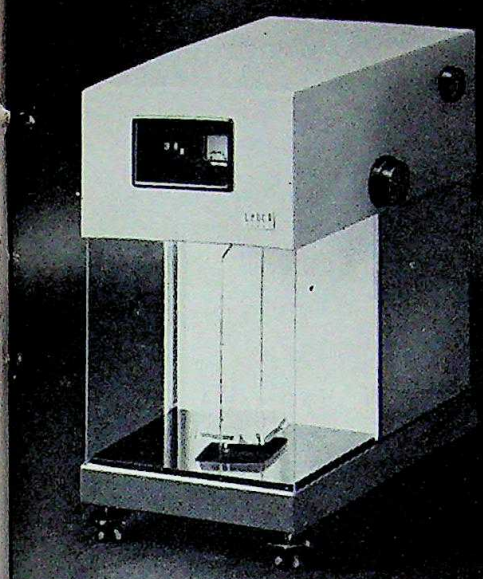

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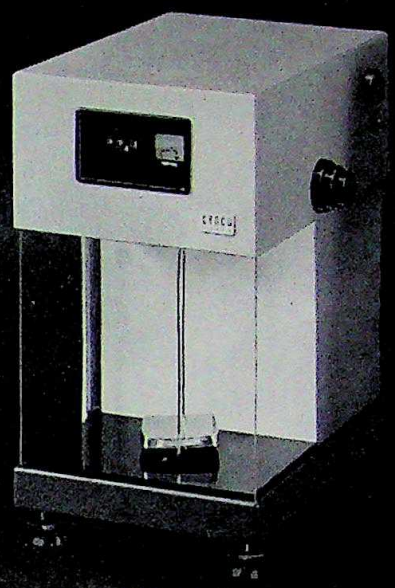

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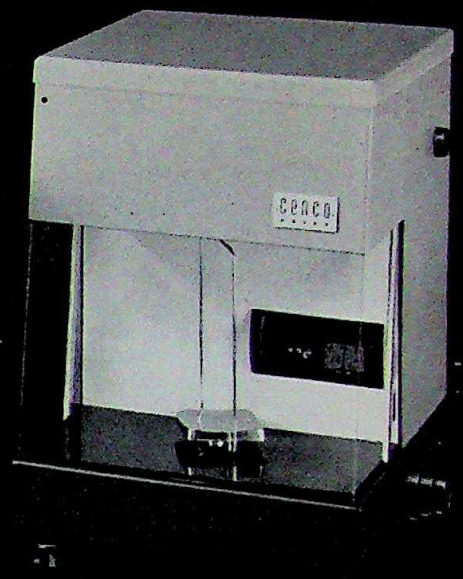

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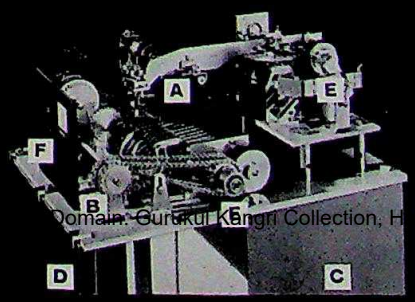

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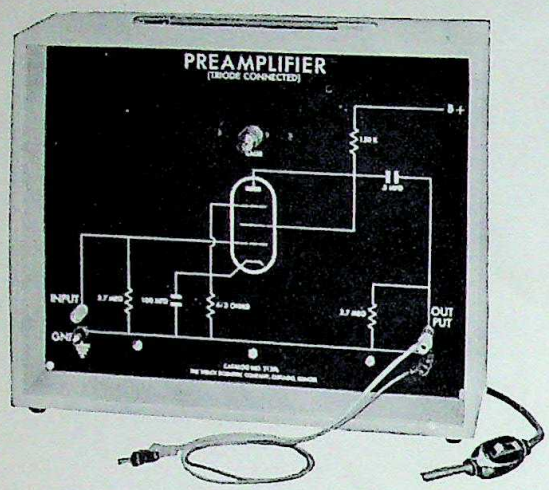

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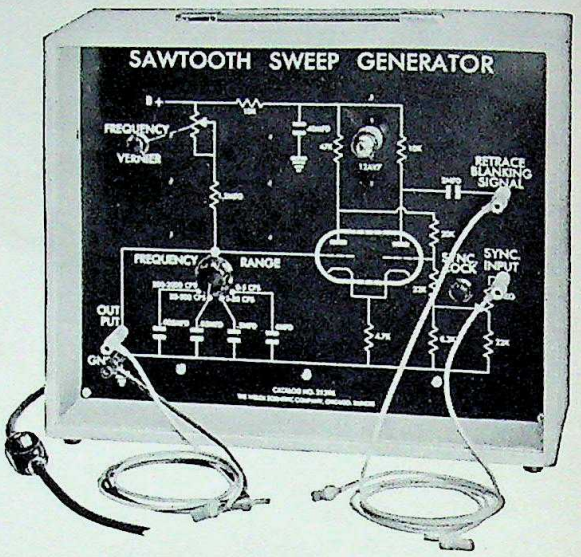

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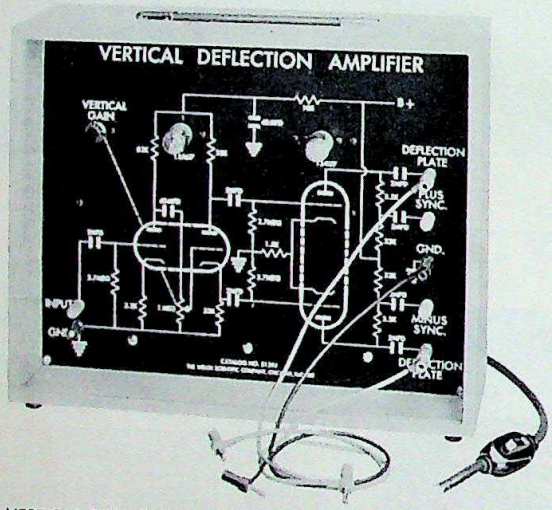

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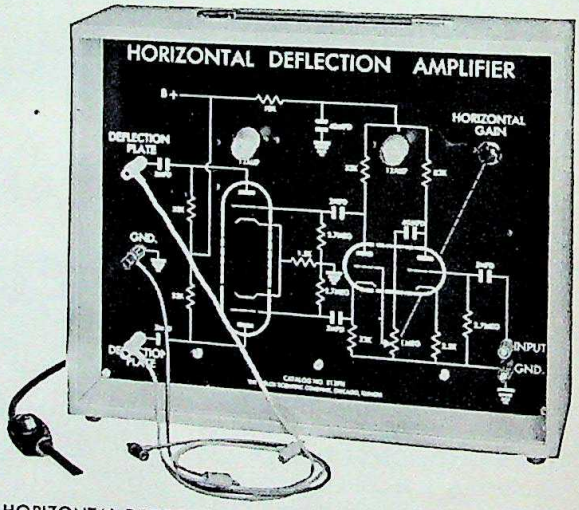

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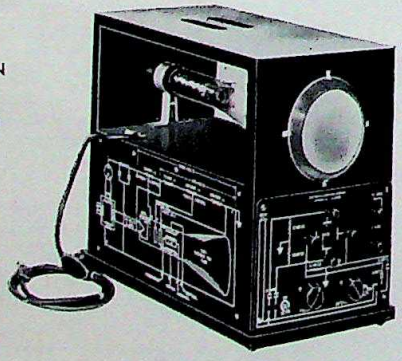

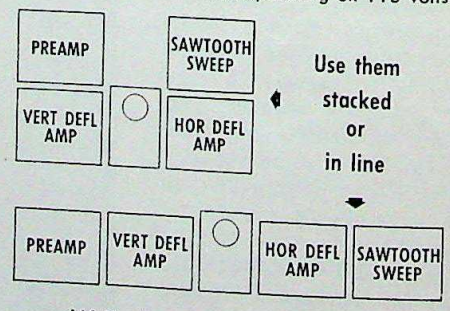

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Chem Ed

EDITORIALLY SPEAKING

Two recent publications by the NSF provide data on scientific manpower of interest to those who counsel students on careers. The summary data in "Scientific Manpower—1962," NSF63-31, (Government Printing Office $0.35) supply answers to often-asked questions. For example:

Job openings reported for scientists, engineers, and technicians by the Department of Labor increased during 1962... for chemists and other natural scientists, 60% or more; for engineers, 40%; and for technicians in these fields, the demand nearly tripled.

The projections indicate an increase in requirements for more than 700,000 new engineers (including replacement of losses) by 1970 in addition to the more than 800,000 engineers employed in early 1960. This rate indicates a need for about 70,000 new engineers entering the field annually, compared with projected graduating classes in engineering averaging about 34,000.

The demand for new scientists is expected to total about 300,000 (including replacements) more than the 335,000 employed in early 1960 to meet expected needs for nearly 600,000 natural scientists by 1970. This rate indicates a need for nearly 30,000 new scientists annually, a figure which approximates the number of new science baccalaureates expected to become available for such work each year.

Among fields of science, largest proportionate growth in requirements is expected for mathematicians, which may more than double in the decade. Needs for physicists, medical scientists, and biological scientists are expected to nearly double. Largest absolute growth is expected for chemists, although the projected rate of growth is slower than the over-all average.

The prospects for meeting these demands of society for trained personnel "appear generally good." The only data at hand, of course, are numbers telling how many students are doing what at present. Trends can be seen, and factors recognized, if not evaluated.

Graduate degrees awarded in the sciences and engineering continued to rise at higher rates than did the number of bachelor-level degrees (in 1962).

Engineering doctorates increased 28% to 1200; master's degrees increased 9% to 8900; bachelor's degrees declined 3% to 34,700.

In the natural sciences (including mathematics), doctoral degrees rose 9% to over 4300; master's degrees increased 11% to 11,300; bachelor-level degrees increased 7% to about 55,700.

The totals of all college degrees awarded in 1961–62 increased over those for the previous year: doctorates rose 10%; master's 8%; bachelor's and first-professional degrees about 5%.

In engineering, there was a 17% rise in doctoral candidates (9200); 8% increase in master's degree students (35,400); the total undergraduate enrollment decreased slightly, but the number of freshmen dropped by 4% to 64,700.

Total graduate student enrollments in all natural sciences increased by about 6% to 60,700. Enrollments in physical science increased less, 3% to 26,600.

The NSF channeled $84 million during fiscal year 1962 into education and training programs in scientific and engineering fields. This represents an increase of about one third more than the amount allocated for these purposes in the previous year.

The other publication, a formidable volume of numerical data in tables and graphs, is "Two Years After the College Degree" NSF63-26 (Government Printing Office $1.75). This report deals with the post college careers of about 40,000 students who graduated in June 1958.

Over one third of the college graduates had attended graduate or professional school by 1960. The proportion of those seeking graduate degrees was highest among pre-med, philosophy, biological sciences, physics, history, and chemistry bachelor's degree holders... Of the degree candidates, close to 60% sought the master's degree, 12% the PhD, and 10% each law and medicine degrees. 87% of the master's degree candidates were women.

High concentration of credits in the major field was a characteristic of graduates who obtained their degrees in fields where the bachelor's degree can be a professional degree (e.g., engineering)... There seems to be little "waste" of those trained in fields for which there is much demand. By and large, those who majored in engineering, mathematics, the sciences, foreign languages, and health fields found employment in these areas... A feeling of being "overeducated" for the job was expressed by only 20% of the respondents, much less often by teachers than by respondents in other occupations... Also those working as scientists and research assistants in all fields least often felt "underutilized."

The data speak clearly: scientists and engineers can feel a security based on the demands of modern life. Although there are jobs at all levels, ample educational opportunities suggest the obligation to base a career on the highest possible degree of training and competence. The reward will be a life work both significant and satisfying.

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Armin Wilson and
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Cyclobutane Chemistry

1. *Structure and strain energy*

The planar character of the skeletal carbon atoms of the cyclobutane ring has been accepted as a fact by organic chemists for many years (*1*). Modern textbooks of organic chemistry still continue to promote this idea, despite the existence of a variety of physical evidence that tends to restrict the catholicity of this concept (*2*). While the evidence for a "bent" or "folded" cyclobutane ring is neither as extensive nor as definitive as in the cyclohexane series, the data obtained during the last decade has nonetheless consistently tended to establish a warped skeleton for many of the simpler derivatives. Since the chemistry per se of these small rings has recently become both voluminous and, more important, fascinating, these conformational commentaries should properly be incorporated into the teaching of cyclobutane chemistry.

Physical Approaches to Structure

We shall review briefly some possible limiting factors in the physical studies of structure before we consider in detail the various conformations that have been proposed for particular four-membered rings. One central fact about these small alicyclic rings should be borne in mind: They are dynamic systems with finite conformational possibilities. This fact is often forgotten in considerations employing graphic formulas or molecular models (*3*). At best these are a frozen photograph of our conception of the real molecule and not, unfortunately, a moving picture film of conformational events in the molecule.

Instrumental probing for the molecular parameters on which we base our ideas of physical structure is likewise limited. One should bear carefully in mind that different techniques convey to us different kinds of raw information (*4*). Infrared and Raman measurements tell us essentially all that we need to know about the structure of a molecule even with their existing powers of resolution. Unfortunately, we can decipher this message fully only for very simple two- or three-atom molecules. By comparison, X-ray and electron diffraction techniques are only rough estimates. However, these latter techniques do allow us to locate relatively all the atoms except hydrogen even in fantastically complex structures (the hydrogen locale is presently accessible by NMR and neutron diffraction techniques).

Hence we will find on occasion that infrared or Raman techniques will suggest one conformer while X-ray or electron diffraction will suggest another. To some extent our difficulties in reaching a wholly satisfactory decision are based on the instrumental difficulties outlined above. There are also deeper underlying philosophical reasons. Pitzer cites an instance in his work with cyclopentane in which certain investigators felt unable to accept his "rippling" set of conformers for the cyclopentane molecule because of the "structural uncertainty" imposed by this concept (*5*). A remark made by Bertrand Russell some years ago is apropos in this connection: "There has been a great deal of speculation in traditional philosophy [read: chemistry] which might have been avoided if the importance of structure, and the difficulty of getting behind it, had been realized (*6*)." We are all familiar with the ancient proverb that "A thing is what it is and what it is becoming." We are further familiar with a specific application of the proverb; that is, the particle-wave duality of the electron. Such duality becomes manifest when we impose a "signal" on an electron and obtain a readable signal in return. The quality of the electronic state suggested by the signal, that is, particle or wave, depends on the particular type of perturbation. This uncertainty extends also to the molecule, which is considered to be a collection of electrons in orbitals that bear to each other and to the particular nuclei involved a most complicated set of quantal interrelationships. The echo of the principle of indeterminacy can still be heard then within the larger confines of molecular architecture. Therefore we can readily perceive that information fed back to us by instrumental interference with the processes that give "life" to the molecule is apt to consist in a multiplicity of answers rather than a yes or no answer concerning a "pet" conformation imagined by some one investigator.

The immense complexity of problems of molecular symmetry is indicated by recent developments in conformational work on the cyclohexane molecule, especially the machine computations of Hendrickson (*7*). We see here that the simple $Chair_1$-$Chair_2$ relationship is no longer a sufficient basis for explaining all of the structural aspects, properties, and reactions of cyclohexane. We appear to be confronted also in the cyclobutanes with the problem of dealing with a molecule that presents itself in various shapes, our knowledge of which is dependent both on the technique used to gather the structural parameters and probably to an even greater extent on our primitive understanding of the nature of the motions of the atoms attached to the quantized chemical bond.

Structural studies, though fraught with dangers inherent in the interpretation of instrumental data, are nevertheless of overwhelming importance for the chemistry of cyclobutane. There is no doubt that such studies will involve more precise application of the older techniques and that newer, more incisive tech-

A second article which will appear next month will discuss the reactions and mechanisms in cyclobutane chemistry.

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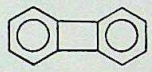
niques will be added. This growth and refinement of techniques is absolutely essential, since we shall have to know what the relatively-relaxed molecule, disturbed only by its surrounding twins, "looks like" before we can make a reasonably sound estimate of the particular shape of the transition state for a given reaction of this molecule. Since the chemistry of cyclopropane and cyclobutane together forms a class that might properly be dubbed "the chemistry of the abnormal or pathological C—C bond," we shall need as full an energetic and geometrical description of these molecules as possible. Such finely-detailed structural studies are mandatory to the unraveling of this truly delightful chemistry.

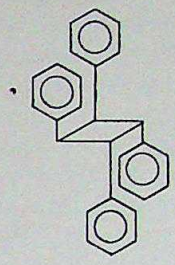
There are three cyclobutane conformations which have received the greatest attention as structural candidates in X-ray and electron diffraction studies. These include the D_{4h} planar, D_{2d} planar and the D_{2d} nonplanar (Fig. 1). Simple cyclobutanes tend in general to display a folded ring of symmetry D_{2d}. The dihedral angle *theta* formed between the two intersecting planes of the ring has an average observed value of about 20° for most of these compounds (*2*). However, Bastiansien has recently reported a dihedral angle of 35° for the parent hydrocarbon (*8*). The tendency toward ring-warping across the diagonal is, logically enough, thwarted by fusion of other rings with the cyclobutane skeletal carbon atoms. Biphenylene (I) for example, contains a captive cyclo-



I

butane ring in the center of the molecule and has been found by X-ray analysis to be perfectly flat. A further comment on the structure of this molecule is to be found in the chemical reactivity: the substitution reactions of biphenylene tend to be those of a ring-fused cyclobutane rather than those of a similarly-constituted cyclobutane or cyclobutadiene (*9*).

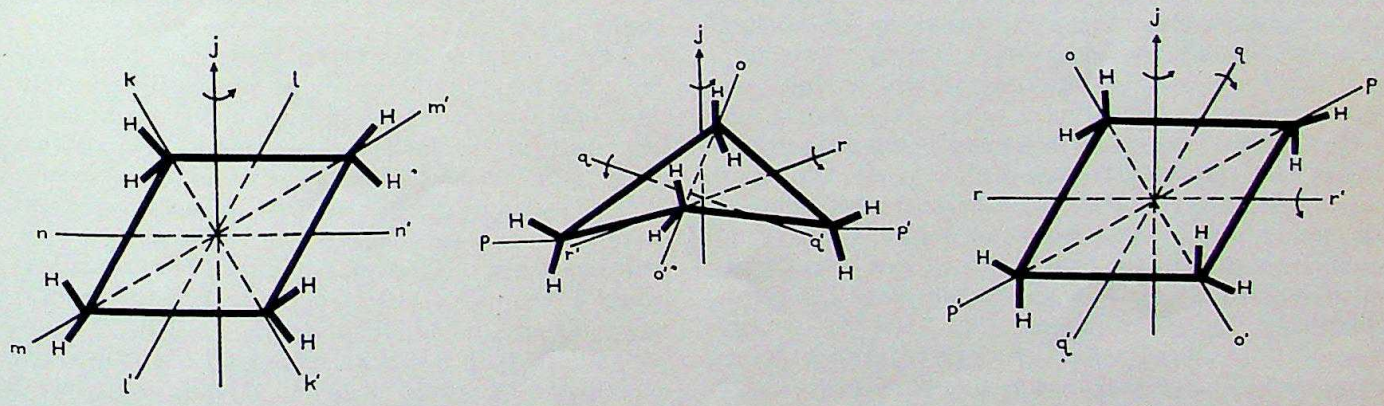
X-ray analysis also indicates a flat cyclobutane ring and centrosymmetry in the isomer of 1,2,3,4,-tetraphenylcyclobutene (II) in which the consecutive pairs

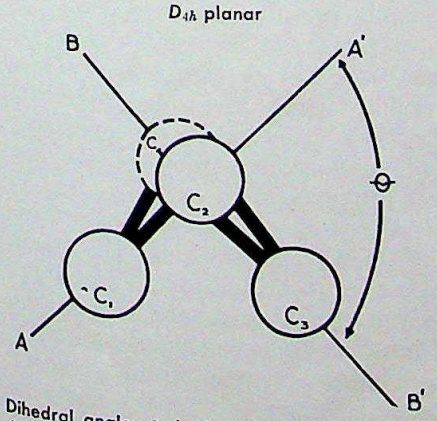


II

of phenyl substituents are alternately *cis* and *trans* around the ring (*10*). The carbon skeleton in the molecule is rectangularly disposed, reflecting possible contributions of *cis* repulsions of the phenyl groups to the lengthening of the alternate skeletal bonds. However, Meredith and Wright have suggested on the basis of measurements of the dipole moment that this isomer is neither flat nor rigid (*3*). The *cis* phenyl groups of the model are not free to rotate completely but are confined to an oscillatory motion about the C-phenyl to C-cyclobutane bond (*11*). The role of crystal forces in determining the "flatness" of this particular cyclobutane ring is not known.

With the limited data at our disposal, we can make only a gross estimate of the factors that fundamentally determine whether or not a cyclobutane with a given set of substituents will have a warped or a planar ring.





Dihedral angle, θ, is the angle between plane *A, A'*, containing carbon atoms C_1, C_2, and C_4, and plane *B,B'*, containing C_2, C_3 and C_4.

Figure 1. The *D* (dihedral) class of molecular point groups to which these three conformers belong, is characterized by a vertical principal axis, *j*, and two-fold subsidiary axes perpendicular to the principal one. The description is completed by consideration of various planes of symmetry that may be either vertical or horizontal. Thus, the D_{4h} planar form has a four-fold principal axis, *j*, (therefore D_4) and a *horizontal* plane of symmetry (therefore D_{4h}) to which the vertical planes of symmetry *k, k'; l, l'; m, m'; n, n'* are subsidiary. (Vertical planes indicated by their lines of intersection with the horizontal plane of the ring.) D_{2d} non-planar has a two-fold principal axis, *j*, (therefore D_2) and two *diagonal* (vertical) planes of symmetry (therefore D_{2d} or sometimes V_d), *o, o'; p, p'* that bisect the angles between the two subsidiary two-fold axes *q, q'; r, r'*. The latter symmetry elements also hold for the D_{2d} planar form.

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The observed entropy of the parent hydrocarbon is, for example, too large to be accounted for by a simple planar form of D_{4h} symmetry alone. Therefore the structural order of this substance is greater than one, and a mixture of conformers must be present. There are also too many bands in the infrared absorption spectra at room temperature to be accounted for on the basis of the allowed frequencies of the D_{4h} planar form. Rathjens and Freeman have on the basis of these measurements put forward the suggestion that an inversion occurs which encompasses the two possible D_{2d} nonplanar conformations as the extreme structures and the D_{4h} planar form as the mid-structure of the process (*12*) (Fig. 2). The barrier hindering this inversion is very low; as the temperature increases, the population of the planar form will increase rapidly at the expense of the bent or staggered forms.

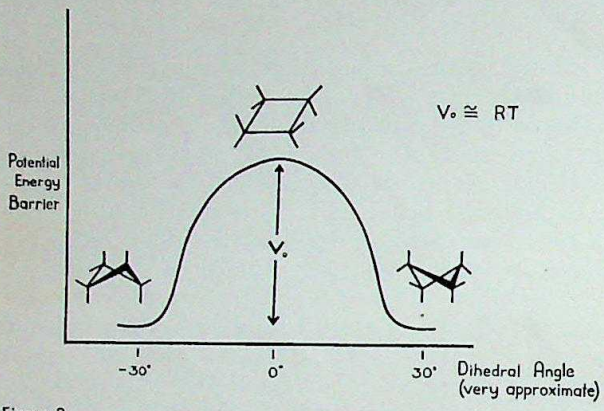

Figure 2.

The introduction of simple substituents into the cyclobutane ring leads to a similar picture. Electron diffraction and X-ray studies on octafluorocyclobutane, methylcyclobutane, and other monocyclic cyclobutanes are suggestive also of D_{2d} nonplanar conformations. A third possible conformation, D_{2d} planar (Fig. 1), was ruled out in the electron diffraction study of octofluorocyclobutane (*13*).

Recent work concerned with physicochemical properties of the cyclobutanes also points to possible ring-folded conformers. Brewster has suggested that a diagonally-folded (D_{2d} symmetry) cyclobutane ring would best explain the similarity of the observed and calculated values of the optical rotation of the caryophyllenic acid stereoisomers (*14*). Roberts' group has, moreover, used a buckled-ring model to explain an unusual magnetic spin-spin coupling between the proton and a fluorine nucleus separated by five consecutive saturated bonds in 1,1-difluoro-2,2-dichloro-3-phenyl-3 methylcyclobutane (*15*). On the negative side, Hollis has run high and low temperature NMR studies on a group of substituted cyclobutanes and has found no perceptible change in the spectra over the range from approximately −70 to +90°C (*16*). Therefore, if these protons are subjected to an averaged environment from dynamic ring buckling, the onset of the ring buckling occurs well below −70°C. (The other, less attractive alternative is that the ring is frozen in one position and remains locked in that position throughout the given temperature range.) This latter finding is in contrast to the work of Jensen on cyclohexane (*17*). He observed a definite splitting of the ring proton signal in cyclohexane as the temperature was lowered. One source of all these difficulties in structural determination in addition to the two mentioned above is possibly to be found in the fact that the cyclobutanes are one of those strange transition structures lying between highly-strained, small cyclic structures such as cyclopropane and spiropentane, and the larger, relatively strain-free alicyclic hydrocarbons, cyclopentane, and cyclohexane. As such, cyclobutane partakes somewhat of the characteristics of each class.

Strain Energy of Small Rings

Molecular strain, like the more general term molecular stability, assumes various meanings for the chemist (*18*). The organic chemist who is faced with the problem of rationalizing the "go" or "no-go" of a small-ring reaction will look upon strain as a bond property that affects the rate or over-all result of the reaction in a special way. If the ring breaks open under exceptionally gentle circumstances, strain is thought of as the property of the bond that is responsible for facile cleavage. The bond at which cleavage occurs is thus considered weaker than normal. If the solvolysis of a small ring halide is unusually slow, strain is invoked as the property of the transition state which forestalls its production in sufficient quantities to permit a normal rate (*19*). On the other hand, the chemical physicist is generally not concerned with the consequences of strain in reactions but is concerned instead with strain as something which contributes to abnormal physical properties in the "resting" or ground state molecule (*20*). The concrete expression of strain for the latter may be an unusual value of the dipole moment (*21*), an "off-value" of a thermodynamic function that points to an unusual conformational population, or a bond force constant that is smaller than usual.

Thus a working definition of molecular strain which is satisfactory for all schools is not easily set down. We could consider strain in a limited sense to be the departure of the intraring sp^3 carbon orbitals from their normal tetrahedral mode, as found in cyclohexane. A bond maladjustment of this type is usually considered to raise the total bond energy and thus make the molecule less stable. However, strain is not, as we shall see, solely a destructive force tending to tear the molecule apart under any and all circumstances (*22*). Further, strain imparts to a ring a complex set of motions over and above the normal ones (*3*). Hence, the origin of strain in molecules and its ultimate effect on the physical and chemical properties of a given molecule are still phenomena that elude comprehensive definitions. We shall therefore merely review below certain aspects of strain energy of concern to the operating chemist and attempt to point out some of the less well-known features of the problem.

Kaarsemaker and Coops have determined calorimetrically a value of 26 kcal per mole for the strain energy of cyclobutane or 6.5 kcal per methylene group (*23*). This observed value demonstrates that the ring is indeed strained but does not permit a clearer interpretation of the nature of this strain. Several semi-empirical calculations have led to the same or somewhat higher values than the one observed (*20, 24, 25*). These latter calculations are not surprising since

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any calculation today involving a ring as large as cyclobutane necessarily involves very broad estimates and considerable guesswork (*20*). In addition, the uncertainties in conformational assignments noted in the last section indicate that we lack a secure model on which to base calculations of the physical parameters of bond strain, such as bond force constants, the degree of departure of bond angles from their normal values, torsional effects (bond-twisting), and the effect of repulsive (or attractive) forces between the nonbonded atoms.

The qualitative picture of strain that emerges from the reactions undergone by cyclobutane and its derivatives is likewise not very enlightening, although certain general tendencies can be observed which are reagent-dependent. We have long been aware of a tendency of the ring C—C bonds to sever under a variety of chemical circumstances.[1] Further, as Roberts and his students have found, the cyclobutane framework is a flimsy, collapsible structure under conditions favoring carbonium ion formation at the ring carbons (*26*). A remarkable equilibrium is established under these circumstances in which cyclobutyl fragments coexist with cyclopropyl carbinyl, open chain, and other forms which still defy adequate description. Nonetheless, there are many circumstances under which cyclobutane (and cyclopropane) rings maintain their curious structure intact, in particular, when treated with certain oxidizing agents (*27*, *28*). Hopefully, improvements in techniques of separating mixtures and in spectral techniques such as NMR, ESR, and mass spectrometry will enable small ring chemists in the next few years to unravel much of this confusion and, finally, to achieve a firm understanding of the "rules of order" for the strained bonds in these molecules.

Although the gross structure of cyclobutane as a four-membered, "saturated" hydrocarbon ring has long been settled, the more arduous task of precisely defining the electronic and energetic composition of the C—C and C—H bonds is still in the primitive stages. However, a monumental conceptual step forward was made by Coulson and Moffitt in 1949 (*29*). The manner in which they attempted to solve the problem of the unusual C—C bond character of these small rings is instructive even today for the organic chemist. The original paper is still, in our view, required reading for those engaged in research or in teaching about small rings. The fact that the junior author, William Moffitt, was 24 years old at the time this paper was published, forms an interesting social as well as scientific commentary.

Their basic contribution was the full pursuit of the intuitive idea that the principle of maximum overlap of atomic orbitals was not inviolate. The consequent implication of a "straight-line" bond was therefore subject to reconsideration. The approach of Coulson and Moffitt enables us to see clearly and generally that a tetrahedral C—C bond can under circumstances of strain depart from tetrahedral symmetry, T_d, to the lower symmetry, C_{2v}, in small rings (Fig. 3). Even under these conditions the carbon-carbon orbitals involved can still provide a bond of considerable strength. A grasp of the implications of this concept is essential to an understanding, not only of small ring chemistry generally, but also of other related phenomena such as the Thorpe-Ingold effect (*30*).

They proceeded by selecting the "hybridization ratio"[2] of the ring carbon orbitals as the variational parameter of the molecule and minimized the energy of the molecule in terms of this ratio. Their calculations show that in the minimum energy state of a small-ring molecule, the ring carbon orbitals in, for example, cyclopropane, are at an angle of 106° to each other and not at 60°, as would be required by straight line bonds. Thus the orbitals are not in a condition of regular sp^3

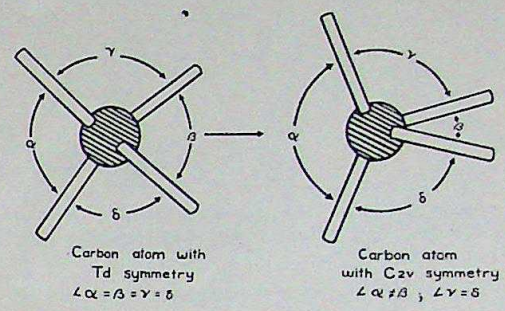

Figure 3.

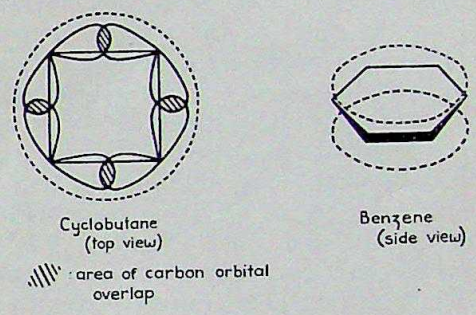

Figure 4.

tetrahedral overlap but are actually bent outward from the hypothetical internuclear straight line. This effect, while not so pronounced in cyclobutane, is nonetheless still present to the extent of about 20% as compared to cyclopropane. This poor overlap engenders in turn a certain amount of electron delocalization (pi character) which contributes to the stability of these ring bonds. These bent bonds are thus seen to be made up of contrasting forces: Poor overlap of the orbitals, which are nominally sp^3, tends to reduce the strength of the bond below that of a structurally comparable C—C bond in, for example, ethane or cyclohexane, while the consequent possibilities for electron delocalization contribute a stabilizing force. One should note carefully that this latent pi character of these bonds is oriented in the *same plane* as the ring carbons and not in two planes parallel to the ring as in benzene. These bent orbitals can be depicted as shown in Figure 4 and the residual pi orbital overlap by the dotted lines. This unusual type of orbital with its dual character has important chemical and physical implications. The pi character inherent in this bent ring bond has been known empirically for many years. The facile ring-opening of cyclopropane with bromine and the more reluctant ring-opening that results on the catalytic hydrogenation of cyclopropane and cyclobutane with Raney nickel catalyst are well-known

[1] *Cf.* part 2 of this paper to be published in THIS JOURNAL.

[2] This term dictates how much "*p*-orbital character" shall be mixed with the *s*-orbital to provide a proper bonding orbital for a given symmetry.

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examples of this ethylene-like behavior (*25*). Subsequent developments have disclosed that both of these small rings, when appropriately substituted, can be cleaved readily with a wide variety of reagents. This array of chemical cleavages is thus indicative of a special property of these small ring bonds. This can be generally attributed to an availability of electrons of the ring bonds considerably above that of a normal sigma C—C bond. For the moment, super electron availability in these bonds can be ascribed to "pi-like character" as the handiest common coin of bond language.

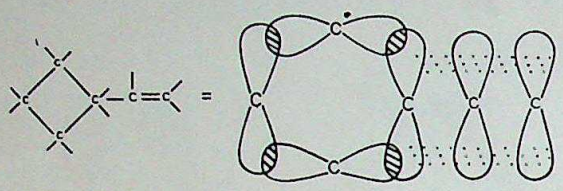

Figure 5. Vinylcyclobutane. Dotted area indicates main pi orbital conjugated with the ring. Slanted line area indicates sigma orbital overlap of ring carbons.

Thus one would expect conjugative powers for these small ring bonds similar to but considerably weaker than ethylene This has been demonstrated by Cromwell on the basis of the spectral properties of conjugated systems which incorporate a cyclopropane ring as a substitute for one of the ethylenic units (*31*). According to Cromwell, conjugation of a clear-cut pi-electron system such as a vinyl or carbonyl group can occur with these small rings only when the bent orbitals of the small rings are in the same plane with the pi orbitals of the attached group (Fig. 5). While somewhat controversial, Cromwell's views are supported by his data which is part of a growing body of evidence indicating that cyclopropane, at least, does possess conjugative powers similar to ethylene. The evidence for the cyclobutane ring is not as abundant or as definite but even here some conjugative ability appears possible (*32*). This ethylene-like character is curiously absent in reactions with oxidizing agents. Neither cyclopropane nor cyclobutane are known to be attacked by ozone (*28*). However, cyclohexane, which is certainly more strain-free and more "aliphatic" in character than these small rings, is largely converted on prolonged ozonization into a mixture of products of which cyclohexanone and adipic acid have been identified (*33*). All of this work should probably be repeated under the control of a single investigator. In view of the known sensitivity of many cyclobutane derivatives to light, ozonization of this small ring in the presence of light might prove interesting.

This stability to oxidizing agents may conceivably be rooted in the unusual pi characteristics of these bent ring bonds as indicated by the work of Coulson and Moffitt. While these bonds are characterized as bent *away* from the hypothetical straight line joining the ring carbon nuclei, they are at the same time bent below the tetrahedral angle of 109°.[3] They should thus be designated as a kind of super sp^3 or sp^{3+} hybrid orbital. There is unfortunately no simple way of relating this hypothetical concept to the observed stability of small rings to oxidants. This is, however, not the usual stability of a closed pi system since such systems are fragmented by ozone. Here is an area in which, as Pauling has suggested, the pi-sigma concept of bonding meets a practical test of survival and from which such a concept may not emerge intact (*34*).

However, with these reservations, the very valuable orbital details of these small rings given by Coulson and Moffitt enable us to "see" the bond-weakening affects of strain in these molecules at the level of the electron pathway as well as to understand the possibility of the existence of residual ghost pi orbitals that encircle a molecule and thus bind it together in spite of the strain. Further, Coulson observed that there is possibly an area of increased electron density in the center of the cyclopropane molecule. As Coulson himself has said in another connection, further theoretical progress in the area of orbital strain should properly await the amassing of definitive laboratory work (*35*). The theoretician may thus know more clearly that which he must describe in precise terms and enlarge upon predictively.

A square planar model with local symmetry C_{2v} at each carbon atom was used by Coulson and Moffitt in their work on the disposition of ring orbitals in cyclobutane. As we have seen, evidence for the presence of crumpled conformations in cyclobutane has continued to accumulate since that paper was written. While the departure from planarity is considered to be small, relative to a molecule such as cyclohexane, renewed attempts at a quantum mechanical description of this molecule should take these conformations into account. Since strain energy and conformations are intimately related, a qualitative review of certain conformational aspects of this molecule can be of assistance in our attempts to understand the sources and effects of strain.

There are many anomalies in small rings that are as yet begging for a clear explanation. One such problem arises from the fact that the ring bond of cyclopropane is slightly shorter (1.524 Å) than a normal C—C single bond (1.540 Å) whereas that of cyclobutane is somewhat longer (1.548 Å). A strained bond, because of its increased tendency to undergo cleavage with the appropriate reagents, would be considered as weaker and, therefore, longer. Coulson and Moffitt explained the short bond in cyclopropane as follows: Since the bond is bent, the line of maximum electron density which corresponds to the actual bond will follow an arc which is of greater length than the hypothetical straight line joining the carbon nuclei. The actual bond is therefore said to be longer than one is led to believe by, for example, electron diffraction studies, which locate only the relative position of the nuclei. However, the long bond of cyclobutane is clearly not explainable solely on the basis given for cyclopropane.

In our efforts to unravel such puzzling molecular features, we are forced to consider and weigh simultaneously the contributions of a multiplet of conformations. As we have noted before, one can no longer elaborate structural theory for these small rings on the basis of a rigid, inflexible nuclear framework. Even the smallest of the cyclic molecules, cyclopropane, probably undergoes a continual change of conformations similar to cyclopentance (*36*). This alleged change would be manifested by a torsional hydrogen staggering in

[3] Coulson and Goodwin (*J. Chem. Soc.*, 1962, 2851), have recently carried through a rough M.O. calculation of these C—C bond angles: cyclopropane, 108° 48′, and cyclobutane, 111° 28′.

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consequence of single carbon oscillation (Fig. 6).

The conformational alterations in cyclobutane must become even more involved because of the additional methylene group. Dunitz and Schomaker have suggested that a prime cause of the long bond in cyclobutane might well be the cross-ring repulsion of the

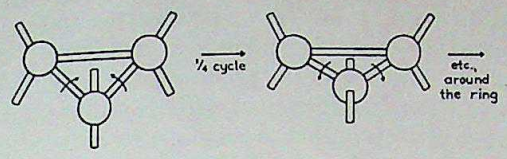

Figure 6.

1,3 carbon atoms (*37*) (Fig. 7). This would not be possible in cyclopropane, since each carbon is bound to only two neighbors. Hence none of the carbons in this ring "looks at" a middleman carbon. In support of this proposed repulsion in cyclobutane, they cite the fact that the 1,3 pair of carbon atoms is 0.3 Å closer (2.2 Å) together than the corresponding 1,3 carbon atoms in cyclohexane (2.5 Å). Consequently, the repulsive forces between these diagonal pairs of carbon atoms in cyclobutane should be considerable.

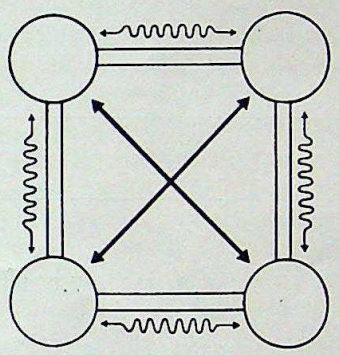

Figure 7.

This proposal is an attractive one conceptually and points to a possible explanation of a good part of the strain energy in cyclobutane. Herein may lie also an explanation of the bending of the ring. Let us assume that the molecule would either have to expand in one plane (breathing) or twist out of the plane with a coupled torsional motion in order to compensate for this repulsion. The latter seems more plausible, since rotation about a bond can normally be accomplished with a smaller expenditure of energy than bond-stretching. The twisting in cyclobutane would involve most logically a diagonal pair of carbon atoms or, rather, both pairs simultaneously.

This would appear to be a more economical route for a four-membered ring than the single carbon twist characteristic of cyclopentane. Using this assumption one can account for the many observations of the form of D_{2d} symmetry in electron diffraction and X-ray work. The only alternative is to insist that such cross-ring repulsion would tend to maintain the carbon nuclei in the same plane. The latter avoids certain conceptual weaknesses in the former argument but fails to explain the structural observations.

Since the molecule does show a tendency to escape the planar conformation, we should examine all of the possible means of increasing the stability of the molecule in the bent form. For this purpose we should, of course, like to relate cyclobutane to a simpler model. The barrier to free rotation of the two methyl groups comprising ethane is probably in the last analysis a very simple example of strain energy. We could imagine cyclobutane as a substituted ethane in which two vicinal protons are replaced by a dimethylene bridge. However, after 30 years of prodigious effort, even this simple manifestation of strain is still wrapped in friendly controversy (*38*).

Another possible approach to cyclobutane, still largely empirical, is the recently proposed "principle of minimum bending of orbitals" under development by Eyring and his group (*39*). This principle is based on one of the most difficult areas of quantum mechanics,

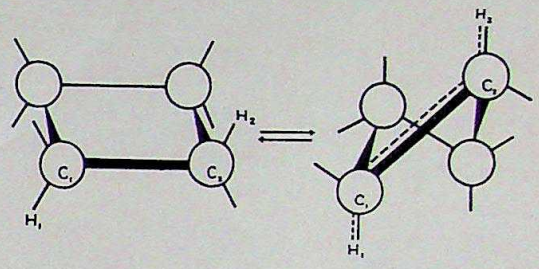

Figure 8.

that of the kinetic energy of the bonding electron. However, this rule appears to us to be capable of considerable conceptual development and holds out the promise of lending assistance in problems such as this one. Re-examination of the problem of dihedral bending in cyclobutanes in the light of this principle yields a partial answer to the riddle of "Why the molecule bends at all." Conceivably, the planar molecule could be pulled into the D_{2d} conformation by the opportunity for a *trans* electron delocalization involving the H_1—C_1—C_2—H_2 nuclei (Fig. 8). The right side of this equilibrium would be terminated by a new set of growing forces that would tend in turn to push this conformational equilibrium toward the left. These new forces are the repulsive ones that would be increasing as carbon atoms 1 and 3 approach each other and the angles between the ring bonds decreased. This scheme would entail a loss of co-planarity as the molecule departs from the planar form. Hence, any stabilization resulting from electron delocalization in the plane of the ring would be sacrificed. However, as noted above, this effect is presumably not very large in cyclobutane. Some gain in stability would occur as a result of an eightfold (or sixteen for the two D_{2d} forms) *trans* staggering of nonbonded H atoms.[4] We are thus able to explain the following observations:

1. There can be two coexistent conformations, D_{4h} and D_{2d}, in dynamic equilibrium.

2. The C—H bonds would be somewhat stronger than those in ethane because of increased delocalization of the C—C bonding electrons toward the C—H bonds in cyclobutane. This has been verified experimentally by the observation of an increased H—C—H angle to 112° (increased sp^2 character). Some additional stabilization of the C—H bond may also be realized through relaxation of the nonbonded H—H repulsion (*40*).

Another unique manifestation of strain energy in

[4] There are actually two sets of spacially nonequivalent ring hydrogens which come into being as the ring bends (see Fig. 1). The axial set achieves coplanarity with the associated carbon nuclei at a dihedral angle of about 60°. The equatorial set, of course, does not.

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certain cyclobutanes is the case with which they decompose to ethylenes. In a manner of speaking, these four-membered rings appear to possess a built-in memory of their ethylenic origin. Thus cyclobutanes in many instances can be neatly broken into their component ethylenes by thermal urging. Srinivasan and Kellner demonstrated in an elegant study of the pyrolysis of cyclobutane 1,1,2,2-d_4 at low pressures that a unimolecular decomposition occurs as illustrated in Figure 9 (*41*). No CH_2CD_2 was observed in thermal splitting of mixtures of cyclobutane and cyclobutane d_8, so we have reasonable assurance that the pyrolysis of cyclobutane is of the simplest possible type: a unimolecular C_2—C_2 split uncomplicated by hydrogen

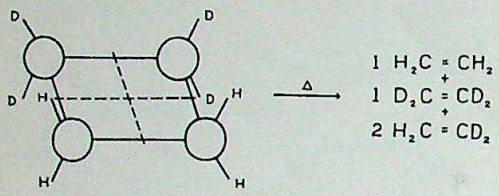

Figure 9.

exchange. Neat fragmentation can also occur in the liquid phase. For example, Gundermann in his studies on the cyclodimerization of β-mercaptoalkylacrylonitriles to the respective cyclobutanes has also observed quantitative splitting of the dimer into the monomer under the proper conditions (*42*). Reverse cyclodimerization has, of course, long been known to occur when cyclobutane photodimers are exposed to "short" ultraviolet light (*43*).

The ready reversibility of some of these reactions present a possible opportunity for the study of strain energy in four-membered rings by the use of appropriate kinetic and thermodynamic techniques.

Two Unsolved Problems

The dimerization of ethylene to cyclobutane has not been observed. The prospects of such an accomplishment are discouraging when viewed historically. Ethylene has indeed been exposed to an enormous variety of experimental conditions which were calculated to produce higher molecular weight hydrocarbons. In no instance has cyclobutane appeared in the products. However, much of this work was done before the advent of gas chromatography and hence trace amounts would probably have gone undetected. Infrared and Raman spectral measurements which have been done on the products of such work are open to question. Attempts to identify peaks definitely characteristic of a unique ring motion (skeletal vibrations) for cyclobutane in these spectral regions have not been successful (*44*). One thermochemical calculation showed a small (minus 25 kcal) but favorable enthalpy change for this cyclodimerization (*45*).

Pease analyzed the problem indirectly some years ago in a paper concerned with ethylene polymerization (*46*). He pointed out that a "quasi-molecule," C_4H_8, consisting of two activated ethylene molecules would have a vanishingly small lifetime. During this short time the sum of the activation energies of the two ethylene molecules would have to be jettisoned in a quantized fashion. Such energy dumping is therefore subject to the dictates of the uncertainty principle and the principle of the conservation of momentum. The transition state of this cyclodimerization, if achieved at all, must resemble two loosely-bonded molecules of monomer. We assume that under these circumstances very few degrees of internal freedom would be available. Consequently, there would be little probability of "concealing" any sizeable amount of additional molecular energy within the incipient bonds for any length of time. Nor would the similar electronegativities of carbon and hydrogen contribute to stability in this instance. All these factors argue against the existence of a stable (long-lived) excited state in sufficient population numbers to permit the reaction to move down the product side of the energy hump.

Several related reactions which have been discovered recently offer some promise that the cyclodimerization of ethylene will eventually be achieved, although in a manner more elaborate than the purely thermal. The reactions listed below are rough analogues of this cyclodimerization in one way or another. However, in each instance some special assistance factor is present:

(1) The photocyclization of myrcene to β-pinene (*47*).

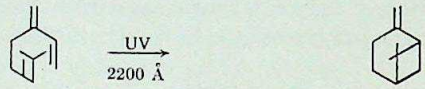

Table 1

Ring size	Number of carbon atoms in ring 4	5	6	7
Borohydride reduction of monoketone[a] ($k_2 \times 10^4$ 1 mole^{-1} sec^{-1})	264.0	7.01	161.1	1.02
Solvolysis of tosylates[a] at 70° ($k_1 \times 10^5$ sec^{-1})	26.7	32.2	2.37	60.0
Solvolysis of 1-chloro-1-methyl cycloalkanes[a] at 25° ($k_1 \times 10^2$ hr^{-1})	0.224	132.0	1.06	115.0
Solvolysis of allylic bromides[b] (relative rates at 0°C)	1.0	3500.0	2.7	...
Dissociation constants of ketone cyanhydrins at 20°C in 95% ethanol,[d] ($k \times 10^2$)	0.87	1.91	0.176	9.53
Oxidation of cycloalkanes by chromic acid[e] rates per methylene group ($(k_{ox/n})\ 10^2\ k_{ox/n}$)	0.0640	1.26	0.212	2.98
Enol content of monoketone (%)[f]	0.55	0.09	1.18	0.56
Ratio of dissociation constants of 1,3-*trans*-dicarboxylic acids (K_a^1/K_a^2)[g]	29.5	11.2	26.0	...

[a] Brown, H. C., and Ichikawa, K., *Tetrahedron*, 1, 223 (1957); *cf.* also Streitwieser, A., *Chem. Rev.*, 56, 667 (1956).
[b] Kiefer, E. F., and Roberts, J. D., *J. Am. Chem. Soc.*, 84, 786 (1962); the original article should be consulted for structures of the particular bromides.
[c] Gutsche, C. D., and Smith, T. D., *J. Am. Chem. Soc.*, 82, 4070 (1960).
[d] *Ibid.*, footnote 22.
[e] Mareš, F., Roček, J., and Sicher, J., *Coll. Czech. Chem. Comm.*, 26, 2362 (1961).
[f] Gero, A., *J. Org. Chem.*, 26, 3157 (1961).
[g] Brown, H. C., et al., in "Determination of Organic Structures by Physical Methods," Braude, E. C., and Nachod, F. C., eds., Academic Press, New York, 1955, Vol. 1, p. 625; *cf.* Gould, E. S., "Mechanism and Structure in Organic Chemistry," Holt, Rinehart and Winston, New York, 1959, p. 242.

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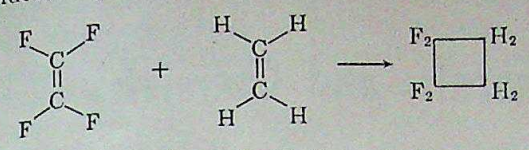
(2) The cross cyclodimerization of ethylene and tetrafluoroethylene (*48*).



(3) The dimerization of ethylene to linear butenes in the presence of weak Lewis acids (*49*).

$$2\,H_2C = CH_2 \rightarrow CH_3 - CH = CH - CH_3 + CH_2 = CH - CH_2CH_3$$

Some years ago Roberts and Chambers made a thorough study of the properties of alicyclic ring compounds (*50*). In general, they found that a number of properties would indeed change in a more or less regular fashion as one ascends the series. However, in the course of preparing this review, we observed a curious alternation of properties which was particularly marked for the subset, cyclobutane, cyclopentane, cyclohexane, and cycloheptane. These are tabulated below for the C_4-C_7 hydrocarbon derivatives.

We cannot possibly judge whether the similarity of properties between cyclobutane and cyclohexane derivatives is indeed indicative of the participation of a "bent" conformer of cyclobutane. To do so at this stage would be tantamount to invoking the "Rule of Selective Inattention to Data."[5] However, one group of investigators is attempting to locate the "axial" and "equatorial" groups in cyclobutanes by means of microwave spectroscopy (*51*). This investigation and the others cited previously proves, we believe, our general contention: namely, that cyclobutanes "in the real and in the round" are far less symmetrical than the graphitic flat square would imply. If this be so, then chemical evidence for this will begin to occur "at the bench." We can only conclude, with A. M. Whitehead, that "Panic of error is the death of progress (*52*)."

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[5] We wish to thank Dr. Irving Tabachnik of the Schering Corporation for pointing out to us this succinct formulation of this curious rule of human behavior.

Literature Cited

(1) Other pertinent reviews of cyclobutane chemistry include: Roberts, J. R., and Sharts, C. M., "Organic Reactions," John Wiley and Sons, New York, 1962, Vol. 12, p. 1; Vogel, E., *Fortschr. Chem. Forsch.*, **3**, 430 (1955); Vogel, E., *Angew. Chem.*, **72**, 4 (1960); Knunyants, I. L., *Diatkin, B. L., USP. Khim.*, **25**, 785 (1956). (The last review is available on loan in English translation from the Bristol-Myers Library).

(2) Goldish, E., J. Chem. Educ., **36**, 408 (1959).

(3) Meredith, C. C., and Wright, G. F., *Can. J. Chem.*, **38**, 1188 (1960).

(4) Brand, J. C. D., and Speakman, J. C., "Molecular Structure, The Physical Approach," Edward Arnold, London, 1960, p. 251.

(5) Pitzer, K. E., and Donath, W. E., *J. Am. Chem. Soc.*, **81**, 3213 (1959).

(6) Russell, B. A. W., "Introduction to Mathematical Philosophy," George Allen and Unwin, London, 1919, p. 61.

(7) Hendrickson, J. B., *J. Am. Chem. Soc.*, **83**, 4537 (1961).

(8) Lord, R. C., and Stoicheff, B. P., *Can. J. Phys.*, **40**, 726 (1961).

(9) Mak, T. C. W., and Trotter, J., *J. Chem. Soc.*, **1962**, p. 1.

(10) Dunitz, J. D., *Acta Cryst.*, **2**, 1 (1949).

(11) Wilson, A., J. Chem. Educ. **39**, 649 (1962).

(12) Rathjens, G. W., Jr., Freeman, N. K., Gwinn, W. D., and Pitzer, K. S., *J. Am. Chem. Soc.*, **75**, 5636 (1953).

(13) Lemaire, H. P., and Livingston, R. L., *J. Am. Chem. Soc.*, **74**, 5732 (1952).

(14) Brewster, J. H., *J. Am. Chem. Soc.*, **81**, 5489 (1959).

(15) Takahashi, M., Davis, D. R., and Roberts, J. D., *J. Am. Chem. Soc.*, **84**, 2935 (1962).

(16) Personal Communication, Dr. D. P. Hollis, Varian Associates; *cf.*, however, Phillips, W. D., in "Determination of Organic Structures by Physical Methods," Vol. 2, eds. Nachod, F. C., and Phillips, W. D., Academic Press, New York, 1962, p. 452.

(17) Jensen, F. R., Noyce, D. S., Sederholm, C. H., and Berlin, A. J., *J. Am. Chem. Soc.*, **84**, 386 (1962).

(18) Wheland, G. W., "Advanced Organic Chemistry," 3rd ed., John Wiley, New York, 1960, p. 475.

(19) Brown, H. C., *J. Chem. Soc.*, 1266 (1956).

(20) Westheimer, F. H., in "Steric Effects in Organic Chemistry," M. S. Newman, Editor, John Wiley, New York, 1956, p. 533.

(21) Meredith, C. C., *op. cit.*, p. 1187.

(22) Deno, N. C., Richey, H. G., Jr., et al., *J. Am. Chem. Soc.*, **84**, 2016 (1962).

(23) Kaarsemaker, S., and Coops, J., *Rec. trav. Chim.*, **71**, 261 (1952).

(24) Benson, S. W., *J. Chem. Phys.*, **34**, 521 (1961).

(25) Dunitz, J. D., and Schomaker, V., *J. Chem. Phys.*, **20**, 1703 (1952).

(26) Caserio, M. C., Graham, W. H., and Roberts, J. D., *Tetrahedron*, **11**, 171 (1960).

(27) Mares, F., Rocek, J., and Sicher, J., *Coll, Czech. Chem. Comm.*, **26**, 2362 (1961).

(28) Fieser, L. F., and Fieser, M., "Advanced Organic Chemistry," Reinhold, New York, 1961, pp. 535, 544.

(29) Coulson, C. A., and Moffitt, W. E., *Phil. Mag.*, **40**, 1 (1949); *cf.*, Kilpatrick, J. E., and Spitzer, R., *J. Chem. Phys.*, **14**, 463 (1946); and Handler, G. S., and Anderson, J. H., *Tetrahedron*, **2**, 345 (1958); *cf.*, Flygare, W. H., *Science*, **140**, 1179 (1963).

(30) Schleyer, P. v. R., *J. Am. Chem. Soc.*, **83**, 1368 (1961).

(31) Cromwell, N. H., *Record Chem. Prog.*, **19**, 215 (1958).

(32) Wren, J. J., *J. Chem. Soc.*, **1956**, 2208.

(33) Durland, J. R., and Adkins, H., *J. Am. Chem. Soc.*, **61**, 429 (1939).

(34) Pauling, L., "Theoretical Organic Chemistry (IUPAC Kekulé Symposium)," Butterworths, London, 1959, p. 2.

(35) Coulson, C. A., and Skanke, P. N., *J. Chem. Soc.*, **1962**, 2782.

(36) Kilpatrick, J. E., Pitzer, K. S., and Spitzer, R., *J. Am. Chem. Soc.*, **69**, 2483 (1947).

(37) Dunitz, J. D., *op. cit.*, p. 1706.

(38) Pauling, L., *Proc. Nat. Acad. Sci. U.S.A.*, **44**, 211 (1958).

(39) Eyring, H., Stewart, G. H., and Smith, R. P., *Proc. Nat. Acad. Sci. U.S.A.*, **44**, 259 (1958).

(40) Bartell, L. S., *J. Chem. Phys.*, **32**, 829 (1960).

(41) Srinivasan, R., and Kellner, S. M. E., *J. Am. Chem. Soc.*, **81**, 5891 (1959).

(42) Gundermann, K. D., and Huchting, R., *Chem. Ber.*, **92**, 415 (1959).

(43) Mustafa, A., *Chem. Rev.*, **51**, 1 (1952).

(44) Schafer, K., Monter, E., and Wolff-Mitscherlich, E., *Z. Elektrochem.*, **65**, 2 (1961); *cf.*, Ulery, H. E., and McClenon, J. R., *Tetrahedron*, **19**, 749 (1963).

(45) Atkinson, B., and Trenwith, A. B., *J. Chem. Phys.*, **20**, 7541 (1952).

(46) Pease, R. N., *J. Am. Chem. Soc.*, **53**, 613 (1931); *cf.*, also Srinivasan, R., *J. Am. Chem. Soc.*, **84**, 4141 (1962) for recent references on this general problem.

(47) Crowley, K. J., *Proc. Chem. Soc.*, 3341 (1962).

(48) Coffman, D. D., Barrick, P. L., Cramer, R. D., and Raasch, M. S., *J. Am. Chem. Soc.*, **71**, 490 (1949).

(49) British Patent 787,438.

(50) Roberts, J. D., and Chambers, V. C., *J. Am. Chem. Soc.*, **73**, 5030 (1951).

(51) Rothschild, W. G., and Dailey, B. P., *J. Chem. Phys.*, **36**, 2931 (1962) *cf.*, Conia, J. M., et al, *J. Am. Chem. Soc.*, **84**, 4982 (1962).

(52) As quoted by L. Nash in "Elements of Chemical Thermodynamics," Addison-Wesley, Reading, Mass., 1962, p. 91.

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Crystals, Minerals, and Chemistry

The intimate relationship between mineralogy and chemistry was established in the late eighteenth and early nineteenth centuries, when Haüy (1743–1822) and Mitscherlich (1794–1863) examined the relationship between crystal form and chemical constitution. Haüy was convinced that identity of crystal form meant identity of chemical constitution, and conversely, that difference of crystal form meant difference in chemical constitution (*1*). The first of Haüy's convictions was controverted by Mitscherlich's work on the isomorphic character of the potassium acid phosphates and arsenates (*2*); of potassium sulfate, selenate and manganate (*3*), and of potassium permanganate and perchlorate (*4*). The conclusion from this work was formulated by Mitscherlich in his principle of isomorphism[1] which played a notable role in the determination of chemical formulas, valence, and atomic weights. The second of Haüy's convictions was shown to be erroneous when Mitscherlich discovered the dimorphism of sulfur (*5*); and it was finally disproved for compounds, too, when chemists accepted the analytical data from samples of aragonite which contained no strontium. The Haüy school had claimed (*6*) that the strontium commonly found in aragonite structures forced the calcium carbonate to adopt the strontianite structure rather than the calcite structure; the existence of a strontium-free aragonite proved this hypothesis incorrect.[2]

Although the nineteenth century saw many descriptions of mineral substances, many measurements of angles, and elaborate classifications of minerals, the definitive study of crystals had to await the development of X-ray diffraction methods for crystal structure analysis.

Of fundamental importance in connection with this new approach to crystal chemistry were the early structure determinations of W. H. and W. L. Bragg, the empirical ionic radii of V. M. Goldschmidt, and Pauling's "rules" for the determination of crystal structures. Today, additional techniques are available, such as neutron diffraction, nuclear magnetic resonance, differential thermal analysis, and infrared absorption spectroscopy. All of these methods have contributed to a detailed knowledge of crystallography and mineralogy.

Nevertheless, simple chemical analysis gives much information about minerals, and shows that the textbook concepts of stoichiometry must be abandoned when dealing with oxygenated systems in the solid state.

Stoichiometry and Isomorphism

Most chemists are familiar with the two series of carbonates of divalent cations listed in Table 1. Not so well understood, however, is the fact that crystals of these substances often are not "pure" carbonates of a single cation, but contain more than one cation, as in the strontium-containing aragonite which confused Haüy and his adherents. The strontium is not there as a separate strontium carbonate phase. Only one phase is present, with the strontium ions substituted at random for calcium ions in the aragonite structure.

Table 1. Two Isomorphic Series of Carbonate Minerals

Rhombohedral ($R\bar{3}c$)	Formula	Cation Radius (A)	Orthorhombic ($Pmcn$)
Calcite	$CaCO_3$	0.99	Aragonite
Rhodochrosite	$MnCO_3$	0.80	...
Siderite	$FeCO_3$	0.74	...
Smithsonite	$ZnCO_3$	0.74	...
Magnesite	$MgCO_3$	0.66	...
...	$SrCO_3$	1.12	Strontianite
...	$PbCO_3$	1.20	Cerussite
...	$BaCO_3$	1.34	Witherite

Some persons call such a substance an isomorphic mixture, but it is not a mixture in the sense that more than one phase is present. Others would speak of it as a solid solution, but the term solution is so familiarly used in connection with liquids as to imply a lack of spatial organization. To overcome these difficulties, the more general term *isomorphic variant* has been proposed.

Isomorphic variants for both of the forms of Table 1 are common. In the calcite group there are various compositions of iron-bearing smithsonite or zinc-bearing siderite, and crystals containing various amounts of manganese in addition to iron and zinc. In addition to the strontium-calcium variants in the aragonite group, there exist barium-calcium and lead-calcium carbonates. For all these cases it must be emphasized that only a single phase is present. The factor which determines the crystal form of the carbonates is the cation radius, with 0.99 Å representing the value common to both structures. When the cations are in about equal amounts, they tend to assume

[1] Mitscherlich, E. (ref. (*2*), p. 79): *"Ett lika antal atomer, då de äro på lika sätt förenade, frambringa like krystall former, och krystall formen beror ej af atomernas natur, utan af deras antal och föreningssätt."* (Equal numbers of atoms, combined in the same way, produce similar crystal forms, and the crystal form does not depend upon the nature of the atoms but on their number and mode of combination.)

[2] Mitscherlich had already suggested the conjugate of isomorphism in his 1821 paper before the Swedish Academy (ref. (*2*)): *"En och samma kropp, som ar sammansatt af samma ämnen efter samma proportioner, kan antaga tvenne olika former."* (The same body, composed of the same substances, in the same proportions, can take on two unlike forms.)

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specific positions in the crystal lattice, rather than appearing in a random arrangement. The appearance of two kinds of atoms in positions formerly occupied by calcium ions causes the crystal to lose some of its symmetry characteristics, and instead of the internal structure of calcite, the structure of dolomite, $CaMg(CO_3)_2$, and ankerite, $CaFe(CO_3)_2$, is observed. These minerals still belong to the rhombohedral class although their internal (space group) symmetry is lower. To accommodate the larger barium ion, however, a different external form is also required, so that $CaBa(CO_3)_2$ is monoclinic.

Still more complex variants occur among the silicates. While orthoclase is clearly a monoclinic crystal closely approaching the formula $KAlSi_3O_8$, the triclinic plagioclase feldspars which make up the common igneous rocks have compositions intermediate between $NaAlSi_3O_8$ and $CaAl_2Si_2O_8$, so that a particular crystal might have an analysis represented by the formula $Na_{0.68}Ca_{0.32}Al_{1.32}Si_{2.68}O_8$.

Isomorphic Substitutions

The substitution of one ion for another without significant disturbance of the structural arrangement is called *isomorphic substitution* or diadochy. As has already been observed for the equi-atom calcium-barium carbonate, the tendency for this substitution to occur without change in structure depends upon the sizes of the ions or ionic groups involved. Thus sodium, which has about the same ionic radius as calcium, can replace the latter fairly readily and to a significant extent. The larger potassium ion, on the other hand, is either absent or is present only in very small amounts in structures for which the principal cation is calcium.

Although it is frequently true that the substituting ion has the same charge as the substituted one, as in the isomorphic carbonate variants discussed above, the sodium-for-calcium substitution in the feldspars indicates that this is not a rigorous requirement. Here the substitution of monovalent sodium for the divalent calcium of the unsubstituted $CaAl_2Si_2O_8$ has been accompanied by an increase in the silicon content and a decrease in the aluminum content. While the external form remains essentially unchanged by this substitution and charge compensation, the X-ray patterns show that changes have occurred in the positions of ions in the crystal. The Al ion is larger than Si and the Ca ion is larger than Na, so changes in the unit-cell dimensions do occur as an accompaniment of compositional changes. It must be emphasized, however, that the crystal lattice should not be looked upon as defective, in the sense of having vacant positions; merely minor rearrangements have occurred through substitution of sodium and silicon for calcium and aluminum.

Another common occurrence is the addition of hydrogen to a structure, forming (OH) groupings of lower charge than that of the oxygens. The tiny proton cannot substitute for metallic cations in the structural positions previously occupied by them. If hydrogen is to enter the crystal structure, it must do so as hydroxyl, ammonium, or hydronium ions, whose radii are comparable to those of the ions they replace. It can, of course, also occur in the status of water molecules.

Coupled Substitution

Another way in which substitution of cations of dissimilar charge can occur is for the cation substitution to be coupled with an anion substitution. A striking example of this is offered by the isostructural minerals berlinite, an aluminum phosphate ($AlPO_4$), and the low-temperature form of quartz ($SiSiO_4$). Both of these substances show the same symmetry characteristics, and both form right-and left-handed crystals, although one can be considered to have a $+3$, -3 oxidation state and the other a $+4$, -4 oxidation state. For classification purposes, it is often more convenient to fix one's attention on the positive oxidation states alone, and look upon this as a "coupled diadochy" in which AlP substitutes for SiSi. Thus this case can be considered to be similar to the substitution of CaAl for NaSi in plagioclase feldspar, or of CeNa for 2Ca in apatite ($Ca_{10}F_2(PO_4)_6$) to give britholite $Ca_{10-2n}(CeNa)_nF_2(PO_4)_6$).

Substitution of Anions

The disparity in sizes of silicon and phosphorus in one instance, and of silicon and aluminum in the other, preclude the formation of isomorphic variants between the two end members, berlinite and quartz. The hydrogarnets, on the other hand, are the variants connecting the two isostructural extremes represented by the mineral grossular, $3CaO \cdot Al_2O_3 \cdot 3SiO_2$, and tricalcium aluminate hexahydrate, $3CaO \cdot Al_2O_3 \cdot 6H_2O$. The X-ray data demonstrate that both of these compounds and the hydrogarnets $3XO \cdot Y_2O_3 \cdot (3\text{-}n)SiO_2 \cdot 2nH_2O$ have 96 oxygen atoms in the unit cell, and that these oxygens occupy the same structurally equivalent positions in all three compounds (*7*). Since the silicate ions in grossular have the tetrahedral configuration characteristic of SiO_4, it must be supposed that when the silicon atoms are replaced by hydrogen atoms in the "hydrated" compounds at the rate of 4 protons per Si^{4+} (to maintain electrical neutrality), the tetrahedral configuration of the oxygens is maintained. Because of their low scattering power for X-rays, the protons cannot be located by X-ray techniques, but it can be assumed that they are closely associated with the oxygen atoms, at the same time remaining as far removed as possible from each other and from the calcium and aluminum ions. The most symmetrical positions for the protons would be the centers of each of the four triangular faces of a tetrahedron which has an oxygen at each apex. In any case the simplest formulas for grossular and the hydrogarnet variants should be written

$$Ca_3Al_2(SiO_4)_3,\ A_3B_2(SiO_4)_{3-n}(H_4O_4)_n,\ A_3B_2(H_4O_4)_3.$$

Synthetic compounds in which A is Ca or Sr and B is Al or Fe have been investigated. In these formulas the H_4O_4 groups represent "tetrahedral hydroxyls."

The group H_4O_4 can also substitute for phosphate and sulfate in the complex minerals listed in Table 2. In these cases the substitution of the anion must be coupled with cation substitution, because of the difference in the oxidation states of H_4O_4 and the other anions.

The extent to which the simple anion substitutions observed by Mitscherlich in his studies of the isomorphism of phosphates and arsenates can be carried, in complex minerals, was first shown in 1937 in the study

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of the mineral ellestadite (*8*). All the physical properties of ellestadite, a calcium sulfate-silicate $Ca_{10}(F,OH)_2(SO_4)_3(SiO_4)_3$, are similar to those of apatite, with which it is isostructural. Table 3 shows some of the wide range of apatite minerals, all of which may be considered as derivatives of, and all of which are essentially isostructural with, apatite. A predominant feature of all of these minerals is that they contain 24 oxygen atoms per unit cell (except where OH or O substitutes for F) and that the other atoms fit themselves to the pattern set by the oxygens.

Table 2. Mineral Examples of Isomorphic Substitution of Anions

H_4O_4 *substituted for*		
SiO_4	PO_4	SO_4
Hydrogarnets	Griphite	Ettringite
Coffinite	Viséite[a]	
Montmorillonite	Apatite	
Antigorite	Crandallite	
$ZrSiO_{4-x}(OH)_{4x}$		

PO_4 *substituted for* SiO_4

Griphite, a phosphate garnet
Viséite, a phosphate zeolite (analcime)[a]
Berlinite, $AlPO_4$ with quartz structure

SiO_4 *and* SO_4 *for* PO_4

Ellestadite, a sulfate-silicate apatite $Ca_{10}(F,OH)_2(SO_4)_3(SiO_4)_3$

[a] Viséite has a framework structure of the type $A[XY_2O_6]\cdot H_2O$ (X is Al for analcime and Y is Si) in which case the tetrahedral oxygens are linked to form $(AlO_2)^-$, $(SiO_2)^0$, $(PO_2)^+$ and $(H_3O_2)^-$, so that the number of protons associated with the 4 shared oxygens is 3 rather than 4. Except montmorillonite and antigorite, other examples are orthosilicates or orthophosphates.

Table 3. Isomorphic Variants and End Members of the Apatite Group, $Ca_{10}F_2(PO_4)_6$

Mineral	Substitutions for Ca	Substitutions for F	Substitutions for PO_4
Ellestadite	...	...	SiO_4, SO_4[a]
Svabite	...	...	AsO_4[a]
Mimesite	Pb[a]	Cl[a]	AsO_4[a]
Vanadinite	Pb[a]	Cl[a]	VO_4[a]
Pyromorphite	Pb[a]	Cl[a]	...
Fermorite	Sr	...	AsO_4
Belovite	Sr, R.E.	...	...
Dehrnite	Na	OH	CO_3
Lewistonite	K	OH	CO_3, AlO_4(?)
Manganvoelkerite	Mn	O	...
Abukumalite	Y, Th	O	SiO_4, AlO_4
Britholite	Ce, Na	...	SiO_4
Francolite[b]	...	...	CO_3
Dahllite[b]	...	OH	CO_3
Synthetic	Cd[a]	...	...
Synthetic	...	Cl	CrO_4
Synthetic	Na	...	SO_4
Synthetic	Al	...	AlO_4

[a] The substitution is essentially complete (end members).
[b] A distinction between dahllite, containing <1% F, and francolite, containing >1% F, is important with respect to the composition of teeth and bones of living animals as contrasted with fossil teeth and bones.

Oxygen Atoms per Unit Cell

The relation of the number and symmetrical arrangement of oxygen atoms in the unit cell to the existence of isostructuralism is an important crystallochemical criterion for recognition of isomorphic variants. An experimental value of the number of oxygen atoms can be readily calculated from the measured density, the chemical analysis, and the X-ray data on the volume of the unit cell. The equation used is

$$n_0 = \frac{D\,V\,N_0(C_1P_1 + C_2P_2 + C_3P_3 + \ldots)}{M\,\Sigma_c}$$

where

n_0 = number of oxygens per unit cell
D = experimental density
V = volume of the unit cell in cubic centimeters
N_0 = Avogadro's number
M = the atomic weight of oxygen
Σ_c = summation of the weight percentages of oxides
$C_1, C_2 \ldots$ weight percentages of oxides
$P_1, P_2 \ldots$ atomic weight ratios of oxygen to formula weights of oxides (e.g., for SiO_2 this is 32/60.06 = 0.5328.)

There is, however, little probability that this calculation will yield an integer, but the correct integral number of oxygen atoms usually can be ascertained from adequate knowledge of the crystallographic symmetry.

As applied to schallerite (*9*) the calculated number of oxygen atoms is 105.2. This experimental value can now be corrected to the true value by considering the hexagonal symmetry of the crystal.

The crystallographic data indicate that the number sought must be divisible by 2 and probably divisible by 8. Large prime numbers and small multiples of fairly large prime numbers can usually be excluded as highly improbable. Thus, for this particular case, 101, 103, 105, 107, and 109 can be eliminated. Between 100 and 110, the remaining choices are 102, 104, 106, and 108. Inasmuch as 106 represents twice 53, it can be eliminated, but 104 can be split in various ways which are compatible with hexagonal symmetry:

$$104/2 = 52 = 48 + 4 = 6\cdot 8 + 4$$

$$104/4 = 26 = 24 + 2 = 3\cdot 8 + 2$$

It is deduced from such considerations that the number of oxygens in the unit cell of schallerite must be 104, which is within about 1% of the calculated value.

Similarly, for ettringite (*10*), the number of oxygens was calculated from three different sets of analytical data as: 368.3, 395.1, and 401.7. Nevertheless, from striking similarities to the known crystal structure of thaumasite (*11*), it was readily deduced that the only reasonable number is 384, because this number is divisible by 8 but not by 5. The number 5, particularly as a factor, is highly improbable inasmuch as it cannot occur as a generator of symmetry operations.

Ettringite is particularly interesting because comparison of its structure with that of thaumasite indicates that carbonate can substitute for sulfate and silicate. Mutual replacement of sulfate, silicate, and phosphate, as shown in the lower half of Table 2, is not surprising, inasmuch as these groups are all tetrahedral in shape, and their sizes, though different, are sufficiently similar to permit compensating effects through substitutions of cations. Tetrahedral hydroxyls would be expected to be somewhat larger than other tetrahedral groups, and indeed, their occurrence is accompanied by larger unit-cell dimensions than those obtained for comparable anhydrous silicates, phosphates, and sulfates.

The carbonate group, on the other hand, is not tetrahedral, and there is no evidence that the coordination number of carbon in thaumasite differs from its normal value of 3; nevertheless, the X-ray data show that the oxygen atom configuration retains the tetrahedral structure characteristic of sulfate and phosphate. This is shown (Fig. 1) by the comparison of the reflection intensities as a function of interplanar spacings

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for ettringite and for a synthetic calcium carbo-aluminate." The latter can be considered the carbonate end member of the family that has ettringite as the

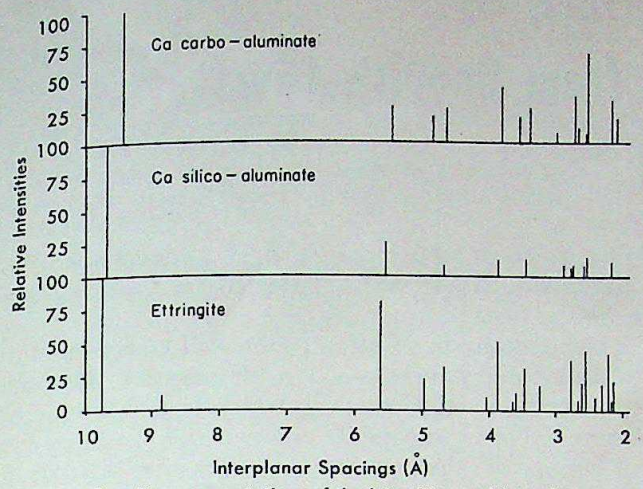
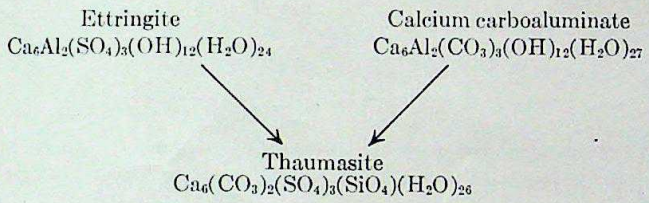


Figure 1. Graphic representations of the intensities and interplanar spacings for the X-ray powder diffraction maxima of calcium carbo-aluminate, calcium silico-aluminate and ettringite, all of which appear to be structurally related to thaumasite. (All data are from publications of the National Bureau of Standards.)

opposite, sulfate, end member, and thaumasite as an intermediate isomorphic variant containing no aluminum.



[3] Haüy, R. J., *Traité de Minéralogie*, Paris, 1822, Vol. 1, p. 503. In the second edition of his treatise, Haüy questions Werner's supposition that certain apatites are not merely mixtures of two phases in the following language: "*A l'égard de la chaux phosphatée grossière de l'Estramadure, il n'y a non plus aucun motif pour la placer dans une espèce à part, ainsi que l'a fait Werner, qui lui a donné le nom 'phosphorit'.*" (With regard to the crude calcium phosphates from Estremadura (Spain), there is no reason at all for placing them in a separate species, as was done by Werner, who gave them the name *phosphorite*.) The term phosphorite is currently used as the name for a rock composed essentially of calcium phosphate minerals (McConnell, D., *J. Geol.*, 58, 16 (1950)).

The carbon atoms in these compounds must be located not at the central site, as for the sulfur or phosphorus atoms, but at the center of a triangular tetrahedral face. Hence, one of the oxygen atoms previously comprising the tetrahedron is away from the sphere of influence of the carbon atom and must shift its positoin slightly to seek other friendly neighbors. This type of substitution appears to be particularly apt in hexagonal structures, and occurs in several of the apatite-like minerals, such as francolite (*12*) and dahllite (*13*) (Table 3), and in rhabdophane (*14*). In fact, the possibility of the existence of carbonate-apatites was suggested more than 140 years ago.[3]

Literature Cited

(1) Haüy, R. J., *Traité de Minéralogie*, Paris, 1801.
(2) Mitscherlich, E., *Kongl. Vetenskaps Academiens Handlingar*, 1821, 4.
(3) Mitscherlich, E., *Ann. Physik und Chemie*, 18, 168 (1830).
(4) Mitscherlich, E., *Abhandl. Konig. Akad. Wiss. Berlin*, 1831, 217.
(5) Mitscherlich, E., *Ann. chim. et phys.*, 24, 264 (1823).
(6) Fuchs, J. N., *J. Chemie und Physik (Schweigger)*, 19, 113 (1817), (became *J. Prakt. Chem.* in 1834.).
(7) McConnell, D., *Am. Mineral.*, 27, 452 (1942).
(8) *Ibid.*, 22, 977 (1937).
(9) *Ibid.*, 39, 929 (1954).
(10) McConnell, D., and Murdoch, J., *Mineral. Mag.* (London), 33, 59 (1962).
(11) Welin, E., *Arkiv Mineral. Geol. (Stockholm)*, 2, 137 (1956).
(12) McConnell, D., *Bull. Soc. Franç. Minéral. Cristal.*, 75, 428 (1952).
(13) McConnell, D., *Am. Mineral.*, 45, 209 (1960).
(14) Fisher, F. G., and Meyrowitz, R., *Am. Minéral.*, 47, 1346 (1962).

Bibliography

Bragg, W. L., "Atomic Structure of Minerals," Ithaca, N. Y., Cornell University Press, 1937.
Eitel, W., "The Physical Chemistry of the Silicates," Chicago, University of Chicago Press, 1954.
Hey, M. H., "An Index of Mineral Species and Varieties Arranged Chemically," London, British Museum, 1955.
de Jong, W. F., "General Crystallography, a Brief Compendium," San Francisco, Calif., W. H. Freeman and Co., 1959.
Lonsdale, K. "Crystals and X-Rays," New York, D. Van Nostrand Co., 1949.
Palache, C., Berman, H., and Frondel, C., "Dana's System of Mineralogy," New York, John Wiley and Sons, 1944 and 1951, Vols. 1 and 2.
Strunz, H., "Mineralogische Tabellen," Leipzig, Geest, and Portig, 1957

"The Naming and Indexing of Chemical Compounds from Chemical Abstracts"

This publication is the introduction to the Volume 56 (January–June, 1962) Subject Index of *Chemical Abstracts*. It represents a comprehensive, 98-page discussion of chemical nomenclature as applied to inorganic as well as organic compounds for systematic indexing, with a classified bibliography, an index, and the appendixes (lists): (I) Miscellaneous chemical prefixes, (II) Inorganic groups and radicals, (III) Anions, (IV) Organic groups and radicals, and (V) Organic suffixes. It should prove to be of great importance and usefulness for every chemist.

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Textbook Errors, 46

Deviations from Raoult's Law

It is often assumed, and has sometimes been stated explicitly in text books,[1] that there are only two thermodynamically possible ways in which a binary mixture can deviate from Raoult's law, namely either that the deviations shall be everywhere positive for both components, or that the deviations shall be everywhere negative for both components. Certainly no such restriction is imposed by thermodynamics and there are in fact several contrary examples.

The only thermodynamic restriction on the partial pressures (strictly fugacities) p_1 and p_2 of the components of a binary mixture is that they must satisfy the Duhem-Margules relation

$$(1 - x)(d \ln f_1/dx) + x(d \ln f_2/dx) = 0 \quad (T, P \text{ constant}) \qquad (1)$$

Here x is the mole fraction of component 2, and f_1 and f_2 are the activity coefficients defined by

$$f_1 = p_1/(1 - x)p_1^\circ, \qquad f_2 = p_2/xp_2^\circ \qquad (2)$$

where p_1° and p_2° are the vapor pressures of the pure substances.

Does equation (1) imply any general restrictions on the signs of $\ln f_1$ and $\ln f_2$, that is on the signs of the deviations from Raoult's law? One such restriction is readily derived but it is a much less severe restriction than that challenged in the first paragraph. Integration by parts of equation (1) between the limits 0 and 1 leads to the equation

$$\int_0^1 \ln(f_1/f_2)\, dx = 0 \qquad (3)$$

which has often been used (*1, 2, 3*) to test liquid-vapor equilibrium data for thermodynamic consistency. Since it follows from (1), equation (3) is a *necessary* condition for thermodynamic consistency, but since it is less restrictive than (1) it is not a *sufficient* condition. For example, the equations in $f_1 = Ax$ and $\ln f_2 = A(1 - x)$ satisfy (3) but fail to satisfy the Duhem-Margules relation (1) and so are thermodynamically impossible. Equation (3) is, however, sufficient immediately to prove that if one component of a binary mixture shows positive deviations ($\ln f_1 > 0$) *over the whole range of compositions* then the other component cannot show negative deviations ($\ln f_2 < 0$) *over the whole range of compositions*, and conversely. No other general restriction on the signs of $\ln f_1$ and $\ln f_2$ can be derived from equation (1).

There remain, in addition to the well-known cases of deviations everywhere positive (or negative) for both components, possible cases in which $\ln f$ changes sign for one or both components between $x = 0$ and $x = 1$. For brevity we shall confine this discussion to kinds of behavior which are not only thermodynamically possible but have actually been observed. In none of these does $\ln f$ change sign more than once for each component.

The excess Gibbs function G^E is defined as the excess of the increase of the Gibbs function on mixing over that for an ideal mixture, and is related (*4*) to the activity coefficients by the equations

$$G^E/RT = (1 - x) \ln f_1 + x \ln f_2 \qquad (4)$$

$$\ln f_1 = (G^E/RT) - xd(G^E/RT)/dx \qquad (5)$$

$$\ln f_2 = (G^E/RT) + (1 - x)d(G^E/RT)/dx \qquad (6)$$

Whereas the composition dependence of $\ln f_1$ and $\ln f_2$ must be such as to satisfy equation (1) the only restriction on the composition dependence of G^E is that G^E shall be zero at $x = 0$ and at $x = 1$. Subject to that restriction any expression for G^E as a function of x will lead to thermodynamically possible activity coefficients by use of equations (5) and (6) since these equations satisfy the Duhem-Margules relation identically.

For the purpose of illustrating unusual kinds of deviations from Raoult's law by specific examples we shall use as a general expression for G^E the series

$$G^E/RT = x(1 - x)\{A + B(1 - 2x) + C(1 - 2x)^2 + \ldots\} \qquad (7)$$

which has often been used (*5, 2, 6*) to fit experimental results, and it will be sufficient for our purpose if we retain only the first three terms. Using equations (5) and (6) with (7) we then obtain for the activity coefficients

$$\ln f_1 = x^2\{(A + 3B + 5C) - (4B + 16C)x + 12Cx^2\} \qquad (8)$$

$$\ln f_2 = (1 - x)^2\{A + B + C) - (4B + 8C)x + 12Cx^2\} \qquad (9)$$

We shall now consider some special cases of equations (7), (8), and (9), first dealing briefly with the well-known cases of *ideal* and of *regular* or *simple* (*4*) mixtures, and then going on to give illustrative examples chosen for their mathematical simplicity, of more unusual but no less thermodynamically possible kinds of behavior.

Case I

The equations for an *ideal* mixture can be obtained if we put $A = B = C = 0$ in equations (7) to (9) so that

Suggestions of material suitable for this column and guest columns suitable for publication directly are eagerly solicited. They should be sent with as many details as possible, and particularly with references to modern textbooks, to Karol J. Mysels, Department of Chemistry, University of Southern California, Los Angeles 7, California.

[1] Since the purpose of this column is to prevent the spread and continuation of errors and not the evaluation of individual texts, the source of errors discussed will not be cited. In order to be presented an error must occur in at least two independent recent standard books.

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$G^E/RT = 0$ $\ln f_1 = 0$ $\ln f_2 = 0$

(An ideal mixture is thus defined by the equation $G^E = 0$. A mixture which obeys Raoult's law is strictly defined by the relations

$$p_1 = (1 - x)p_1^0 \text{ and } p_2 = xp_2^0$$

We remind the reader that we have ignored any distinction between partial pressure ratios and fugacity ratios, and that this is equivalent to ignoring the distinction between an ideal mixture and one which obeys Raoult's law. Our discussion therefore applies strictly to deviations from ideality rather than to deviations from Raoult's law, but the distinction will usually be unimportant.)

Partial pressures for an ideal mixture are shown as broken straight lines in all the following diagrams of the partial pressures of nonideal mixtures.

Case II

The equations for *regular* or *simple* (*4*) mixtures can be obtained if we put $B = C = 0$ in equations (7) to (9). We then obtain

$$G^E/RT = Ax(1 - x) \qquad \ln f_1 = Ax^2 \qquad \ln f_2 = A(1 - x)^2$$

As examples of the behavior of regular mixtures plots of G^E/RT, $\ln f_1$, and $\ln f_2$, and of p_1/p_1° and p_2/p_2° are shown for $A = 1$ (positive deviations from Raoult's law) in Figure 1, and for $A = -1$ (negative deviations from Raoult's law) in Figure 2.

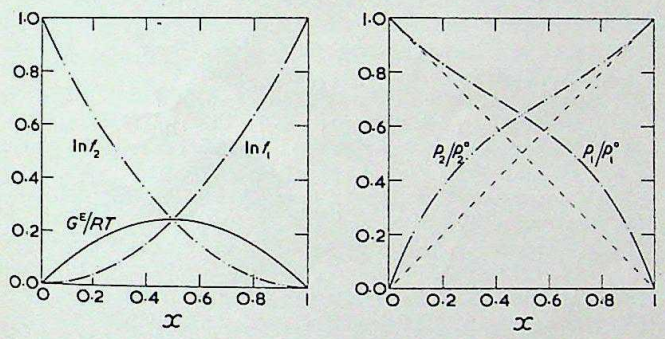

Figure 1. Case IIa: $A = 1, B = C = 0$.

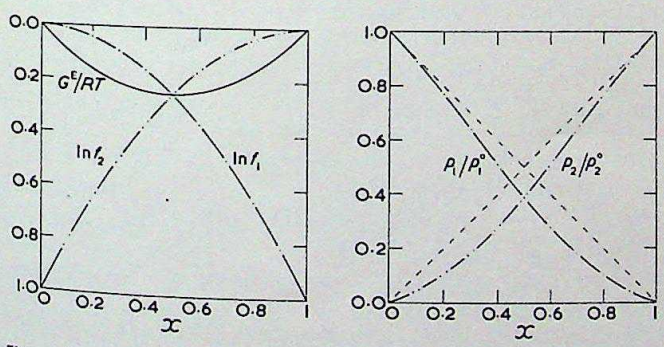

Figure 2. Case IIb: $A = -1, B = C = 0$.

Case III

One kind of unusual behavior can be illustrated if we put $B = -A$ and $C = 0$ in equations (7) to (9). We then obtain

$$G^E/RT = 2Ax^2(1 - x)$$
$$\ln f_1 = 2Ax^2(2x - 1) \quad \ln f_2 = 4A(1 - x)^2x$$

Examples of this kind of behavior are shown for $A = 1$ in Figure 3 and for $A = -1$ in Figure 4.

Mixtures of ethanol and chloroform at 35°C (*7*) give deviations from Raoult's law like those of case III*a* (Fig. 3). So do solid solutions of silver chloride and sodium chloride at 150°C (*8*), the deviations for this pair being large enough to cause a region of partial miscibility. Mixtures of pyridine and water, which according to von Zawidski (*9*) behave like case III*a*, have since been shown (*10*), however, to give deviations which are everywhere positive like case II*a* (Fig. 1).

Mixtures of nitromethane and acetone at 45°C have recently been shown (*11*) to behave like case III*b* (Fig. 4). Liquid mixtures of thallium and mercury at 325°C (*12*), cadmium and antimony at 480°C (*13*), zinc and antimony at 550°C (*14*), and potassium and mercury at 275°C and 325°C (*15*), and solid solutions of lead bromide and lead chloride at 200°C (*16*), have also been shown to behave like case III*b* (Fig. 4).

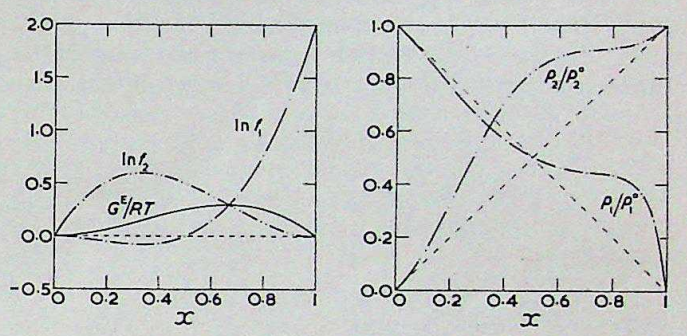

Figure 3. Case IIIa: $A = 1, B = -1, C = 0$.

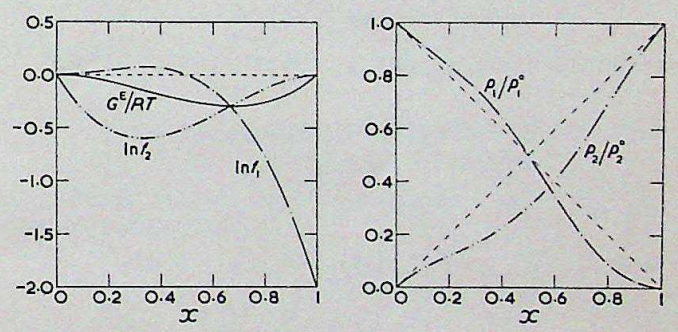

Figure 4. Case IIIb: $A = -1, B = 1, C = 0$.

Case IV

Another kind of unusual behavior can be illustrated if we put $A = 0$ and $C = 0$ in equations (7) to (9). We then obtain

$$G^E/RT = Bx(1 - x)(1 - 2x)$$
$$\ln f_1 = Bx^2(3 - 4x) \quad \ln f_2 = B(1 - x)^2(1 - 4x)$$

An example of this kind of behavior is shown for $B = 1$ in Figure 5.

Solid solutions of *p*-dichlorobenzene and *p*-dibromobenzene at 50°C (*17*) have recently been shown to behave like case IV. The author knows of no other example.

Case V

Finally, yet another kind of unusual behavior can be illustrated if we put $B = 0$ and $C = -A$ in equations (7) to (9). We then obtain

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$$G^E/RT = 4Ax^2(1 - x)$$
$$\ln f_1 = 4Ax^2(1 - x)(3x - 1) \ln f_2 = 4A(1 - x)^2x(2 - 3x)$$

Examples of this kind of behavior are shown for $A = 1$ in Figure 6 and for $A = -1$ in Figure 7.

Mixtures of benzene and bromobenzene at 80°C (*18*) are nearly ideal but have nevertheless been shown to behave like case V*a* (Fig. 6). Liquid mixtures of cadmium and potassium at 475°C (*19*) also behave like case V*a* (Fig. 6), the deviations for this pair being large enough to cause a region of partial miscibility.

Liquid mixtures of bismuth and cadmium at 431°, 477°, and 533°C (*20*) and at 500°C (*21*), and of lead and thallium at 438°C (*22*) have been shown to behave like case V*b* (Fig. 7).

It was shown by Dolezalek (*23*) that deviations from Raoult's law which are everywhere negative (case II*b* (Fig. 2); for example chloroform and ether) can be ascribed to the formation of a 1:1 compound in equilibrium with the parent substances, if it is assumed that the three species together form a ternary ideal mixture. Since then it has been commonly but wrongly supposed that "compound formation always leads to negative deviations from Raoult's law." In fact it has been shown (*24, 25*) that while that statement is true for 1:1 compounds, the formation of any compound *other* than 1:1 always leads to deviations which change sign for one or both of the components. For example the formation of a 1:2 compound leads to behavior like case III*b* (Fig. 4). The formation of both 1:1 and 1:2 compounds in the same mixture can lead either to behavior like case II*b* (Fig. 2) (deviations everywhere negative), or to behavior like case III*b* (Fig. 4) (deviations change sign for component 1), according to the relative amounts formed of the two compounds. Mixtures of chloroform and dioxane which probably form both 1:1 and 1:2 compounds turned out (*26*) to behave like case II*b* (Fig. 2), in spite of the author's hope that they might behave like case III*b* (Fig. 4) and so be another example of unusual behavior.

Apart from the advantages of not telling lies in the lecture room the author has found that these examples of unusual behavior provide a useful way of familiarizing the student with the Duhem–Margules relation and its consequences and applications. Calculations, with various chosen values for the equilibrium constants, of the properties of mixtures in which one or two compounds are formed, have proved a useful exercise for advanced students.

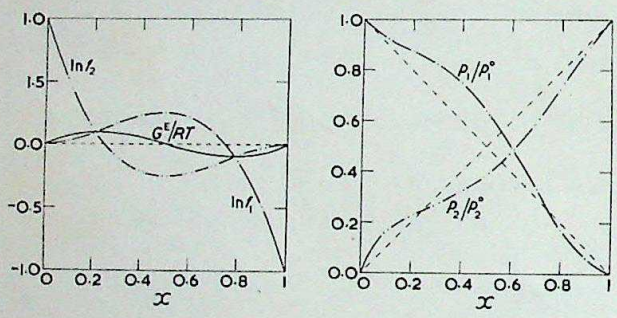

Figure 5. Case IV: $A = 0, B = 1, C = 0$.

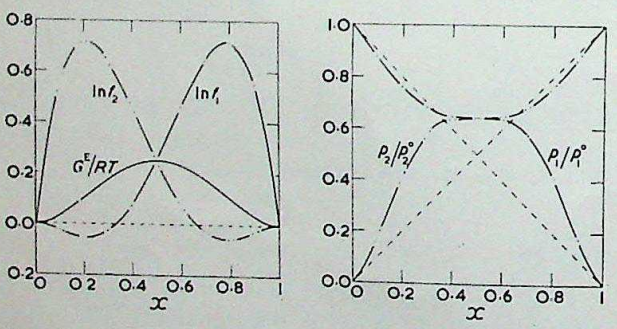

Figure 6. Case V*a*: $A = 0, B = 1, C = -1$.

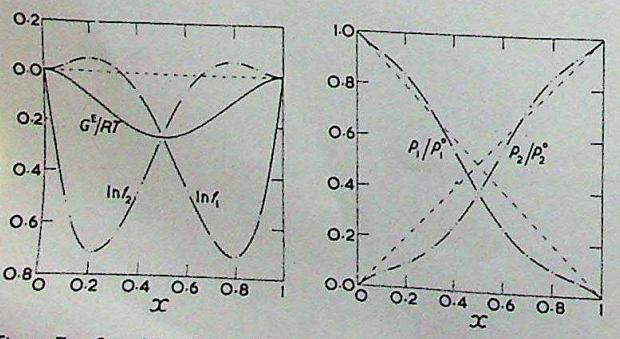

Figure 7. Case V*b*: $A = -1, B = 0, C = 1$.

Literature Cited

(1) Herington, E. F. G., *Nature*, **160**, 610 (1947); Coulson, E. A., and Herington, E. F. G., *Trans. Faraday Soc.*, **44**, 629 (1948).
(2) Redlich, O., and Kister, A. T., *Ind. Eng. Chem.*, **40**, 345 (1948).
(3) Rowlinson, J. S., "Liquids and liquid mixtures," Butterworths, London, **1959**, pp. 132–7.
(4) Guggenheim, E. A., "Thermodynamics," 3rd ed., North Holland Publ. Co., Amsterdam, **1957**, Sect. 5.34. *et seq.*
(5) Guggenheim, E. A., *Trans. Faraday Soc.*, **33**, 151 (1937).
(6) Scatchard, G., *Chem. Revs.*, **44**, 9 (1949).
(7) Scatchard, G., and Raymond, C. L., *J. Am. Chem. Soc.*, **60**, 1278 (1938).
(8) Wachter, A., *J. Am. Chem. Soc.*, **54**, 919 (1932).
(9) von Zawidski, J., *Z. physik. Chem.*, **35**, 129 (1900).
(10) Andon, R. J. L., Cox, J. D., and Herington, E. F. G., *Trans. Faraday Soc.*, **53**, 410 (1957).
(11) Brown, I., and Smith, F., *Austral. J. Chem.*, **13**, 30 (1960).
(12) Hildebrand, J. H., and Eastman, E. D., *J. Am. Chem. Soc.*, **37**, 2452 (1915).
(13) Seltz, H., and DeWitt, B., *J. Am. Chem. Soc.*, **60**, 1305 (1938).
(14) DeWitt, B., and Seltz, H., *J. Am. Chem. Soc.*, **61**, 3170 (1939).
(15) Lantratov, M. F., and Tsarenko, E. V., *Zhur. priklad. Khim.*, **33**, 1539 (1960).
(16) Wachter, A., *J. Am. Chem. Soc.*, **54**, 2276 (1932).
(17) Walsh P. N., and Smith, N. O., *J. Phys. Chem.*, **65**, 718 (1961).
(18) McGlashan, M. L., and Wingrove, R. J., *Trans. Faraday Soc.*, **52**, 470 (1956).
(19) Lantratov, M. F., and Tsarenko, E. V., *Zhur. priklad. Khim.*, **33**, 1116 (1960).
(20) Taylor, N. W., *J. Am. Chem. Soc.*, **45**, 2865 (1923).
(21) Elliott, J. F., and Chipman, J., *Trans. Faraday Soc.*, **47**, 138 (1951).
(22) Hildebrand, J. H., and Sharma, J. N., *J. Am. Chem. Soc.* **51**, 462 (1929).
(23) Dolezalek, F., *Z. physik. Chem.* **64**, 727 (1908).
(24) Metzger, G., and Sauerwald, F., *Z. anorg. Chem.*, **263**, 324 (1950).
(25) Högfeldt, E., *Arkiv. Kemi*, **7**, 315 (1954); *Rec. Trav. Chim.*, **75**, 790 (1956).
(26) McGlashan, M. L., and Rastogi, R. P., *Trans. Faraday Soc.*, **54**, 496 (1958).

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Potentiometric Titration Curves for Simple Ion Combination Reactions

A simple ion combination reaction is one in which the slightly dissociated (either slightly ionized or slightly soluble) product of the chemical reaction is composed of two symmetrical charge type ions.

The rigorously derived (from considerations of electroneutrality and/or material balance) equation which theoretically characterizes a potentiometric titration curve obtained for a simple ion combination reaction is a quadratic with respect to the concentration of either ion involved in the reaction (*1*, *2*). Obviously, an exact solution for the concentration of interest, C, may be obtained via the quadratic formula; subsequently, the negative logarithm of the concentration, pC, may then be obtained (*2*).

Alternatively, one may obtain pC directly, by recognizing that the logarithm of the solution to any quadratic equation may be expressed in terms of the inverse hyperbolic sine of a "titration function" which is dependent upon the fraction titrated, the initial concentration of the species to be titrated, and the dissociation constant characteristic of the reaction product which results from the ion combination. Account may be easily taken of the dilution which occurs during the titration.

This form of the exact equation is not really new, although it does not appear to have ever been considered as providing a relatively easy method for the rigorous calculation of these titration curves, under any conditions. It has, however, been used as a basis for determining endpoints, by Cavanagh (*3*) and Fortuin (*4*).

Investigation of this equation allows one to determine the region, in terms of the "fraction titrated" parameter, f, wherein the exact equation must be used. Outside of this region, the rigorously derived equation reduces to the more commonly used expressions.

It should be remembered that alternatively, a rigorous calculation of a titration curve can always be accomplished by considering the concentration of one of the ions, rather than the fraction titrated, to be the independent variable. Such a procedure is always applicable, and especially useful for titrations which result in the formation of unsymmetrical reaction products, as has been recently emphasized by Bishop (*5*). The equation which will be discussed in this article is applicable only to the formation of a symmetrical reaction product.

The Exact Equation

Consider the simple ion combination reaction:

$$\mathrm{M} + \mathrm{X} = \mathrm{MX} \tag{1}$$

where M and X represent a cation and anion, respectively; the equal in magnitude, but opposite in sign, charges being omitted. MX is the slightly dissociated product for which:

$$K = [\mathrm{M}][\mathrm{X}] \tag{2}$$

where the brackets represent molar concentrations of the indicated species, and K is a concentration (or formal) equilibrium constant, rather than a true thermodynamic one. However, under the usual conditions, this concentration constant remains approximately constant, at least in the vicinity of the equivalence point, because of the approximate constancy of the ionic strength in this region. The smaller the amount of dilution that occurs, the more constant will be the ionic strength. The variation of ionic strength during the entire titration can always be virtually eliminated by use of a large concentration of inert electrolyte.

The complete chemical equation for the titration may be written as:

$$\mathrm{MB} + \mathrm{CX} = \mathrm{MX} + \mathrm{CB}$$

where B and C are the accompanying anion and cation respectively, of M and X.

Therefore, the condition of electroneutrality may be written as:

$$[\mathrm{M}] + [\mathrm{C}] = [\mathrm{X}] + [\mathrm{B}] \tag{3}$$

If we consider that we are titrating V° milliliters of a solution of CX of original molar concentration C°, then the molar concentrations of B and C, at any fraction titrated, f, are:

$$[\mathrm{B}] = \frac{C^\circ V^\circ}{V^\circ + V} f \tag{4}$$

$$[\mathrm{C}] = \frac{C^\circ V^\circ}{V^\circ + V} \tag{5}$$

where we assume the volumes to be additive, and where V is the volume, in milliliters, of the added titrant, at the corresponding fraction titrated, f.

By definition:

$$f = V/q \tag{6}$$

where q is the volume of titrant necessary to reach the equivalence point, at which:

$$C^\circ V^\circ = C_T q \tag{7}$$

where C_T is the molar concentration of the titrant.

Rewriting $V^\circ/(V + V^\circ)$ as $1/(1 + V/V^\circ)$ and recognizing that $V/V^\circ = (q/V^\circ)\,(V/q)$, we then may solve equation (7) for q/V° and write:

$$\frac{V^\circ}{V + V^\circ} = \frac{1}{1 + rf} \tag{8}$$

if we define r as:

$$r = C^\circ/C_T \tag{9}$$

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where r is an auxiliary parameter. f may be considered to be the primary parameter.

Substitution of equation (8) and of [X] from equation (2) into equation (3), yields:

$$[\mathrm{M}] + \frac{C^\circ}{1+rf} = \frac{K}{[\mathrm{M}]} + \frac{C^\circ f}{1+rf} \qquad (10)$$

Two comments should be made concerning equation (10). First, it applies for all values of f (including zero) only for acid-base neutralizations, in which case MX represents HOH; for precipitation titrations, equation (10) is valid only for a nonzero value of f because equation (2) does not apply until some precipitate is formed. Second, if we neglect dilution (i.e., $r = 0$) we obtain the usual approximate equation for electroneutrality. Our definition of the auxiliary parameter, r, is thus logical because the greater the concentration of titrant relative to the concentration of the species being titrated, the smaller is the avlue of r.

Rearrangement of equation (10) to:

$$\frac{[\mathrm{M}]}{K^{1/2}} - \frac{K^{1/2}}{[\mathrm{M}]} = \frac{C^\circ(f-1)}{K^{1/2}(1+rf)}$$

and recognition of the following identity:[1]

$$\frac{[M]}{K^{1/2}} - \frac{K^{1/2}}{[\mathrm{M}]} = \exp\left(\ln\frac{[\mathrm{M}]}{K^{1/2}}\right) - \exp\left(-\ln\frac{[\mathrm{M}]}{K^{1/2}}\right)$$

$$= 2\sinh\left(\ln\frac{[\mathrm{M}]}{K^{1/2}}\right)$$

yields:

$$2\sinh\left(\ln\frac{[\mathrm{M}]}{K^{1/2}}\right) = \frac{C^\circ(f-1)}{K^{1/2}(1+rf)}$$

or:

$$\ln[\mathrm{M}] - \frac{1}{2}\ln K = \sinh^{-1}\frac{C^\circ(f-1)}{2K^{1/2}(1+rf)}$$

where $\sinh^{-1}$ represents the inverse hyperbolic sine. After conversion from natural logarithms we obtain:[2]

$$p\mathrm{M} = \frac{1}{2}pK - \frac{1}{2.303}\sinh^{-1}\frac{C^\circ(f-1)}{2K^{1/2}(1+rf)} \qquad (11)$$

where, as usual, $p\mathrm{M} = -\log[\mathrm{M}]$ and $pK = -\log K$. Making use of the identity: $-\sinh^{-1}x = \sinh^{-1}-x$, we may also write equation (11) as:

$$p\mathrm{M} = \frac{1}{2}pK + \frac{1}{2.303}\sinh^{-1}\frac{C^\circ(1-f)}{2K^{1/2}(1+rf)} \qquad (12)$$

or:

$$p\mathrm{M} = \frac{1}{2}pK + \frac{1}{2.303}\sinh^{-1}F$$

where the titration function, F, is equal to

$$C^\circ(1-f)/2K^{1/2}(1+rf)$$

It is important to emphasize that $p\mathrm{M}$ is symmetrical with respect to F, but F is not symmetrical with respect to f unless dilution is neglected ($r = 0$); thus, in general, $p\mathrm{M}$ is not symmetrical with respect to f. The significance of this is that the theoretically calculated titration curve, which takes account of dilution, is slightly asymmetrical, and therefore the endpoint and equivalence point will not coincide (*6*).

Equations (11) and (12) are equivalent, but prior to the equivalence point it is more convenient to use the latter.

From either equation (11) or (12), it is easily seen that $p\mathrm{M} = (\frac{1}{2})pK$ at $f = 1$, because $\sinh^{-1} 0 = 0$. It is also obvious (from either equation (10) or (12)) that the result of taking the dilution into account is to yield at any particular value of f prior to equivalence, a smaller value of $p\mathrm{M}$ than if dilution is neglected, while (from equation (10) or (11)) at any value of f beyond equivalence the value of $p\mathrm{M}$ is larger than it would be if dilution is neglected. In other words, the calculated curve which neglects dilution intersects with the one which does not at $f = 1$, as it must, because $p\mathrm{M}$ at the equivalence point is independent of dilution and dependent only upon the magnitude of the equilibrium constant.

Approximate Forms of the Exact Equation

For values of F such that $F^2 \gg 1$, i.e., F^2 much greater than unity: $\sinh^{-1} F \simeq \ln 2F$, so that equation (12) may be written as:

$$p\mathrm{M} = -\log\frac{K(1+rf)}{C^\circ(1-f)} \qquad (13)$$

for values of f such that:

$$f \ll \frac{1 - 2K^{1/2}/C^\circ}{1 + 2rK^{1/2}/C^\circ} \qquad (14)$$

Equation (13) is the usual approximate equation that applies before the equivalence point.

If equation (11) is written as:

$$p\mathrm{M} = \frac{1}{2}pK - \frac{1}{2.303}\sinh^{-1}\mathrm{G}$$

then for $G^2 \gg 1$: $\sinh^{-1} G \simeq \ln 2G$, so that equation (11) may be written as:

$$p\mathrm{M} = -\log\frac{C^\circ(f-1)}{1+rf} \qquad (15)$$

for values of f such that:

$$f \gg \frac{1 + 2K^{1/2}/C^\circ}{1 - 2K^{1/2}/C^\circ} \qquad (16)$$

Equation (15) is the familiar expression for the region beyond the equivalence point.

Therefore the exact equation (either equation (11) or (12)) must be used in the region:

$$\frac{1 + 2K^{1/2}/C^\circ}{1 - 2rK^{1/2}/C^\circ} \gg f \gg \frac{1 - 2K^{1/2}/C^\circ}{1 + 2rK^{1/2}/C^\circ} \qquad (17)$$

It is seen that the effect of a nonzero value of r is to slightly extend the region within which we must use the exact equation; also, the portion of the region subsequent to equivalence is somewhat larger in magnitude than that prior to equivalence, unless $r = 0$.

The magnitude of the region defined by equation (17) depends on the value of the equilibrium constant K, the initial concentration C°, and the dilution parameter r. Indeed, it is the ratio $K^{1/2}/C^\circ$, which is of interest rather than the absolute value of either term comprising the ratio.[3] The region within which we can use the customary approximate expressions is increased when

[1] Exp $x = e^x$, $\sinh x = \frac{1}{2}[\exp(x) - \exp(-x)]$.

[2] For the reverse titration, i.e., titration of MB by CX, we obtain:

$$pM = \frac{1}{2}pK - \frac{1}{2.303}\sinh^{-1}\frac{C^\circ(1-f)}{2K^{1/2}(1+rf)}$$

[3] Note that $K^{1/2}$ is the concentration of X at $f = 1$ while C° is its initial concentration, at $f = 0$.

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the initial concentration is increased, the equilibrium constant is decreased, and, or, the dilution parameter is decreased.

Error in Using the Approximate Instead of the Exact Equation

Of considerable interest is the error in pM, ΔpM, which is incurred by the use of the approximate rather than the exact equations.

Prior to equivalence, the value of pM calculated from equation (12) will be greater than that obtained from equation (13); subsequent to $f = 1$, the rigorously calculated value of pM (from equation (11)) will be smaller than that obtained from the approximate formula (equation (15)).[4] At $f = 1$, neither of the approximate equations applies but $p\mathrm{M} = (1/2)\, pK$; thus, at the equivalence point, the theoretical curve calculated from the approximate equations intersects with that calculated from the exact equations.

Let us consider the region prior to equivalence. Defining ΔpM so as to be positive, we may subtract equation (13) from equation (12), to obtain:

$$\Delta p\mathrm{M} = \frac{1}{2}\, pK + \frac{1}{2.303} \sinh^{-1} F + \frac{1}{2.303} \ln \frac{K(1 + rf)}{C^\circ(1 - f)}$$

However,

$$K(1 + rf)/C^\circ(1 - f) = K^{1/2}/2F$$

so by substitution of $K^{1/2}/2F$ into the argument of the natural logarithm, we obtain:

$$\Delta p\mathrm{M} = \frac{1}{2.303} \left[\sinh^{-1} F - \ln 2F\right] \qquad (18)$$

from which it is easy to calculate the error in pM corresponding to any selected value of F. More enlightening is the investigation of the minimum value, a, that F must possess so that ΔpM does not exceed some selected value, b. As equation (18) cannot be solved explicitly for F one must substitute various values for F until one attains the desired value of ΔpM. An extensive table of inverse hyperbolic sines is useful for this purpose (7). The results of these calculations are presented in Table 1 for some representative values of ΔpM.

[4] This can be easily seen because

$$\sinh^{-1} x = \ln 2x + \frac{1}{4x^2} - \ldots$$

consideration of equation (10) leads to the same conclusion.

It is interesting to note that though it is usually thought that F must exceed unity in order to transform the exact equation into the more usual approximate one; in reality, to make an error no greater than 0.10 in the calculation of pM, F need only equal or exceed 0.875. Of course, for values of F less than unity, $\sinh^{-1} F \sim F$ *is a better approximation*, and indeed ΔpM is then reduced to 0.04 for $F = 0.875$.

To find the value of f corresponding to any value of a in Table 1, we use:

$$f \leq \frac{1 - 2aK^{1/2}/C^\circ}{1 + 2arK^{1/2}/C^\circ} \qquad (19)$$

which is derived directly from $F \geq a$. Thus, to make an error of b (or less) in the calculation of pM, we cannot use the approximate equation for any value of f greater than that obtained from equation (19).

Until now we have only considered the region prior to equivalence. However, as previously discussed, pM is symmetrical with respect to F. Therefore, subsequent to equivalence, if ΔpM is still defined as the difference between the approximate (equation (15)) and the exact (equation (11)) equations:

$$\Delta p\mathrm{M} = \frac{1}{2.303} \left[\ln 2G - \sinh^{-1} G\right],$$

where $G = C^\circ (f - 1)/2K^{1/2} (1 + r f)$. Use of the values of a found in Table 1, for G, will result in the same values of b listed there except prefixed by a negative sign.

Table 1. Minimum Values of F^a For Selected Values of ΔpM

a	b
0.875	0.1000
1.35	0.0500
2.25	0.0200
3.23	0.0100

[a] $F \geq a$ for $\Delta p\mathrm{M} \leq b$.

In other words, the exact equation must be used in the region:

$$\frac{1 + 2aK^{1/2}/C^\circ}{1 - 2arK^{1/2}/C^\circ} \geq f \geq \frac{1 - 2aK^{1/2}/C^\circ}{1 + 2arK^{1/2}/C^\circ} \qquad (20)$$

if ΔpM is not to exceed $\pm\, b$; the corresponding value of a being obtained from Table 1 or a similar type of table. For convenience, we may write equation (20) as:

$$f_2 \geq f \geq f_1 \qquad (21)$$

Values of f_1 and f_2 for various values of $K^{1/2}/C^\circ$ are presented in Table 2; $r = 0$ corresponds to neglect of

Table 2. Values of f_1 and f_2 Defined by Equation (21)

$K^{1/2}/C^\circ$	10^{-1}		10^{-2}		10^{-3}		10^{-4}	
	f_1		f_1	f_2	f_1	f_2	f_1	f_2
				$r = 0$				
ΔpM								
0.1000	0.825	1.175	0.982	1.018	0.998	1.002	1.000	1.000
0.0500	0.730	1.270	0.973	1.027	0.997	1.003	1.000	1.000
0.0200	0.550	1.450	0.955	1.045	0.996	1.004	1.000	1.000
0.0100	0.354	1.646	0.935	1.064	0.994	1.006	0.999	1.001
				$r = 1$				
0.1000	0.702	1.424	0.965	1.037	0.996	1.004	1.000	1.000
0.0500	0.575	1.740	0.947	1.056	0.994	1.006	1.000	1.001
0.0200	0.379	2.636	0.914	1.094	0.992	1.008	0.999	1.001
0.0100	0.215	4.650	0.879	1.138	0.988	1.012	0.999	1.001

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dilution; $r = 1$ applies to a titration in which the concentration of the titrant is equal to the original concentration of the species being titrated.

It is evident that for $r \leq 1$, the approximate equation can be used, with an error not exceeding 0.0100 in pM, even at 0.1% titrated prior or subsequent to equivalence, as long as $C^\circ/K^{1/2}$ exceeds 10^4. For acid-base neutralizations, this corresponds to a pH difference of 4.00 units between the initial pH and that at equivalence; thus C° must equal or exceed 1.00×10^{-3} M.[5]

It should be emphasized that because pM is logarithmically related to [M], a relatively large error in [M], results however in a considerably smaller error in pM. This somewhat mathematically fortuitous result does not excuse a student from being able to calculate [M], to as great an accuracy as may be desired, by use of the appropriate formula. However, recognition of this relationship may save considerable time if only a calculation of a titration curve (pM versus f) is required.

A brief consideration of this relationship follows.

Prior to equivalence, the approximate value of [M] from equation (13) is greater than that calculated from the exact equation (12); i.e., $p\mathrm{M}_{\mathrm{approx}} < p\mathrm{M}_{\mathrm{exact}}$.

Thus, if the error in the calculation of [M] is $100\,E_{\mathrm{M}}\%$:

$$E_{\mathrm{M}} = \frac{[\mathrm{M}]_{\mathrm{approx}} - [\mathrm{M}]_{\mathrm{exact}}}{[\mathrm{M}]_{\mathrm{exact}}} = \frac{[\mathrm{M}]_{\mathrm{approx}}}{[\mathrm{M}]_{\mathrm{exact}}} - 1 \qquad (22)$$

From equation (13):

$$[\mathrm{M}]_{\mathrm{approx}} = \frac{K(1 + rf)}{C^\circ(1 - f)} = \frac{K^{1/2}}{2F}$$

and from equation (12):

$$[\mathrm{M}]_{\mathrm{exact}} = K^{1/2} \exp\left[-\sinh^{-1} F\right]$$

so that equation (22) may be written as:

$$E_{\mathrm{M}} = \frac{\exp\left[\sinh^{-1} F\right]}{2F} - 1 \qquad (23)$$

In Table 3 are presented the minimum values that F must possess in order that E_{M} does not exceed the indicated error. Through the use of equation (19) one may estimate the region of f values wherein the exact equation must be employed to obtain [M] to any desired accuracy.[6]

From equation (22), we obtain:

$$\Delta p\mathrm{M} = \log(1 + E_{\mathrm{M}}) \qquad (24)$$

which reflects the lesser dependence on E_{M}, of the accuracy of pM than that of [M]. A ten per cent error in [M], i.e., $E_{\mathrm{M}} = 0.10$, results in only an error 0.04 units in pM; a five per cent error in [M] yields only an error of 0.02 in pM. Thus to calculate pM to within 0.10 unit, it is only required that $E_{\mathrm{M}} \leq 0.26$.

[5] $$p\mathrm{H}_{f=0} - p\mathrm{H}_{f=1} = \frac{1}{2.303}\sinh^{-1} C^\circ/2K^{1/2} \simeq \log C^\circ/K^{1/2}$$

for $C^\circ/K^{1/2} \gg 1$; $K_w^{1/2} = 1.00 \times 10^{-7}$ at 25° C.

[6] For values of

$$f > 1:\ E'_{\mathrm{M}} = \frac{-E_{\mathrm{M}}}{1 + E_{\mathrm{M}}} \text{ where } E'_{\mathrm{M}}$$

is defined by equation (22), but now only applies subsequent to equivalence, and E_{M} is obtained from Table 3.

Table 3. Minimum Values for F for Selected Values of E_{M}

F	E_{M}
1.51	0.100
2.18	0.0500
3.50	0.0200
4.98	0.0100
7.04	0.0050
11.1	0.0020
15.8	0.0010

Summary

Examination has been made of the properties of the rigorously derived equation which is applicable to the calculation of a potentiometric titration curve for a simple ion combination reaction. Under appropriate conditions, expressed in terms of the fraction titrated, the customary approximate equations may be used.

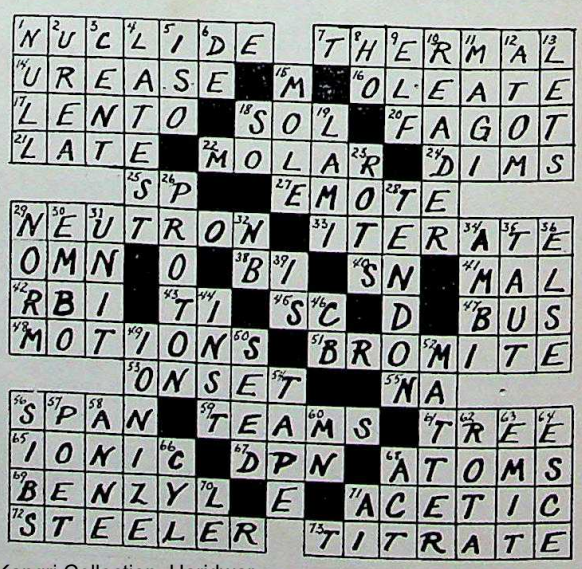
The presentation of the exact equation emphasizes the principle that the complete titration curve may be represented by a single function, i.e., the curve is continuous. Under conditions where the approximate equations cannot be accurately used, the calculation of pM is nevertheless relatively easy as compared to first obtaining [M] by use of the quadratic formula. The use of tables of the inverse hyperbolic sine should present no difficulties and allows the student to become familiar with some properties of hyperbolic functions.

Finally, a brief consideration has been made of the relationship between the error in [M] and in pM.

Literature Cited

(1) Kolthoff, I. M., and Stenger, V. A., "Volumetric Analysis," 2nd rev. ed., Interscience Publishers, Inc., New York, 1942, Chap. 2 and Chap. 3.
(2) Ricci, John E., "Hydrogen Ion Concentration," Princeton University Press, Princeton, 1952, Chap. 9.
(3) Cavanagh, B., *J. Chem. Soc.*, 1928, 857.
(4) Fortuin, J. M. H., *Anal. Chim. Acta*, 24, 175–91 (1961).
(5) Bishop, E., *Anal. Chim. Acta*, 22, 101–5 (1960).
(6) Roller, P. S., *J. Am. Chem. Soc.*, 54, 3498 (1932).
(7) Warmus, M., "Tables of Elementary Functions," Pergamon Press, New York, 1960; Comrie, L. J., "Chamber's Six Figure Mathematical Tables," D. Van Nostrand New York, 1949, Vol. 2.

Solution to the Puzzle on p. 496 of the September Issue.



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Tangent-Sphere Models of Molecules

II. Uses in teaching

Chemistry witnessed this past year a striking event. Synthesized for the first time were compounds of the "inert" gases. Like most events in chemistry, this event was exciting in proportion to the degree that it was unexpected. It served, thus, as a dramatic reminder of a fundamental fact: chemistry is (still) an experimental science. Even today, for example, several decades after the advent of quantum mechanics, chemistry does not possess a satisfactory mathematical theory of systems more complex than the isolated hydrogen molecule. Several reasons for this were examined in Part I. It was concluded there that possibly the Pauli Principle is more important than previously supposed. To explore the chemical implications of this possibility, there was introduced a model in which tangent-spheres were used to represent a combined atom's valence-shell electron pairs—or, perhaps more properly, the "Fermi holes" associated with these electron pairs. This model, it was seen, is capable of representing the salient stereochemical features of conventional, covalent bonds. It is found that the model can also be used to represent highly strained bonds and multicentered bonds, atoms with expanded octets and atoms with contracted octets, intermolecular interactions and intramolecular interactions, and the effects of electronegative groups, lone pairs, and multiple bonds upon molecular geometry, bond properties, and chemical reactivity. These uses of the models are described below, following a summary, in the first three sections, of model uses discussed previously in Part I.

Isomorphism with Valence-Bond Diagrams

Every line or pair of dots in the valence-bond representation of a molecule becomes in the model a sphere, and vice versa. In effect the model is a three-dimensional reconstruction of the two-dimensional valence-bond diagram.[1] Conversely, a valence-bond diagram may be viewed as a two-dimensional projection of a three-dimensional model in which (1) lines are used for protonated spheres (bonds to hydrogen atoms) and for spheres adjacent to two tetrahedral holes (the single bond in ethane, Fig. 5 (Part I), for example, and the components of the multiple bonds in ethylene and acetylene, Figs. 38 and 39); (2) dots are used for unprotonated spheres bordering on a single tetrahedral hole (lone pairs); and (3) letters (H, C, N, O, etc.) are used to indicate locations of protons and other more complex atomic cores.

Gross Details of Stereochemistry

One immediate consequence of the tangent-sphere model is the tetrahedral geometry about atoms involved in four single bonds (Figs. 3 and 5; also Figs. 8–15 (Part I)), the planar geometry about atoms involved in one double bond (Fig. 38), and the linear geometry about atoms involved in a triple bond (Fig. 39) or two double bonds (Fig. 21, Part I).

Finer Details of Stereochemistry

More subtile details of molecular conformation that can be illustrated and discussed with the aid of tangent-sphere models include: the staggered and eclipsed configurations of ethane; the *trans* and gauche conformers of *n*-butane; the equatorial and polar bonds and the chair and boat confomers of cyclohexane (and the more complex confomers of higher perhydroaromatics); the puckered cyclobutane ring; the orientation of groups adjacent to double bonds and the equilibrium shapes of such molecules as acetaldehyde and propylene, 1,3-butadiene, 1,3,5-hexatriene, and 1,3,5,7-cyclooctatetraene; and steric interactions in skew *n*-butane and such other molecules as 2-butene, the isomers of fluoro-propene, and the mono- and di-methyl substituted cyclohexanes (*20*, *21*).

Strained Bonds

Tangent-sphere models can be used to represent not only normal multiple bonds, Figures 38 and 39, but as well the strained, bent bonds in such molecules as cyclopropane, Figure 25, cyclopropene, Figure 26, and benzyne, Figure 27.

Multicentered Bonds (22)

The model of ethylene, Figure 38, can serve equally well as a model of B_2H_6, if one supposes that the heavy atoms in the two tetrahedral holes are boron atoms and that all six spheres are protonated. The relation of

A preliminary account of this work was presented at the Gordon Research Conference in Inorganic Chemistry, New Hampton, N. H., August 6–10, 1962.

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[1] This is an effective way to introduce the models to beginning students who already have had some experience with valence-bond diagrams. The models may be viewed as adding literally another dimension to their knowledge of stereochemistry. With very young students, however, we suspect it might be easier and more "natural" to introduce the models first and their two-dimensional projection diagrams second.

Editor's Note: The first part of this paper appeared in the September issue of This Journal, 40, 446 (1963). Literature citations and figures are numbered consecutively for the whole paper; citations 1–21 and Figures 1–24 appeared in the first part.

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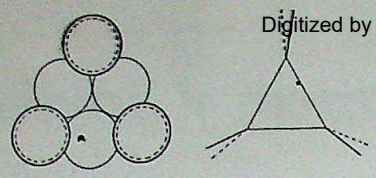


Figure 25. Tangent-sphere model of cyclopropane. Dotted lines represent spheres whose centers lie behind the plane of the paper, heavy lines spheres whose centers lie above this plane. The inner three circles represent carbon-carbon bonds, the outer six carbon-hydrogen bonds. At the right is the corresponding valence-bond diagram.

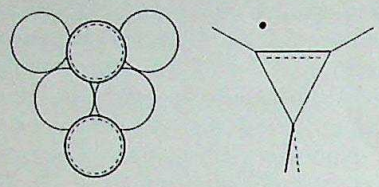


Figure 26. Tangent-sphere model and valence-bond diagram of cyclopropene. Clockwise from 12 o'clock the circles represent C═C (top center), C—H, C—C, CH_2 (bottom center), C—C, C—H.

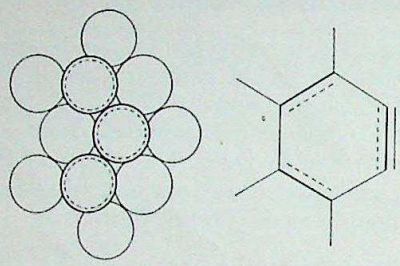


Figure 27. Tangent-sphere model and valence-bond diagram of the triple-bond representation of benzyne. The model is formed from fragments of five close-packed layers containing, from top to bottom (or bottom to top), 1, 4, 4, 4, and 1 spheres. Only the six outer tetrahedral holes (two on the right, two on the left, and one each at the top and bottom) are occupied by carbon nuclei. It may be significant to note that it is apparently impossible to construct an equal-sphere-size model of a six-membered ring containing four double bonds.

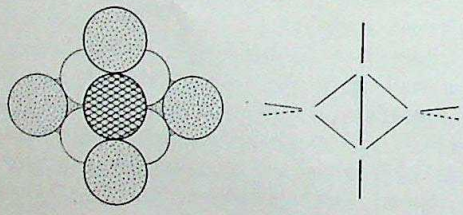
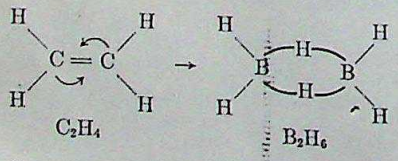
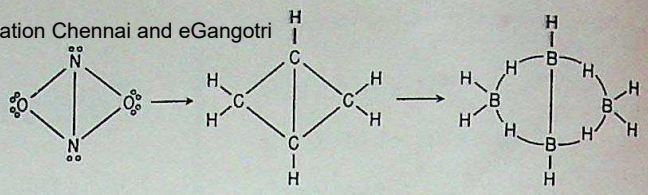


Figure 28. Tangent-sphere model and valence-bond diagram of B_4H_{10}. The model's four tetrahedral holes, which lie N, E, S, and W from the center, correspond to the gaps in the valence-bond diagram at the right. The six stippled circles represent two-centered boron-hydrogen bonds, the four open ones three-centered boron-hydrogen-boron bonds. The cross-hatched circle represents the two-centered boron-boron bond.

this structure to the ethylene structure may be illustrated in two-dimensions as follows (*cf.*, ref. (*31*), p. 306).

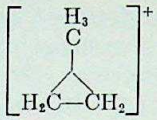


In a similar manner the valence-bond representation of B_4H_{10} can be derived from the following (probably hypothetical (*23*)) bicyclic structure of the dimer of nitric oxide.



The corresponding tangent-sphere representation of B_4H_{10} is illustrated in Figure 28. The B_4H_{10} structure contains four three-centered boron-hydrogen-boron bonds.[2]

Addition of a trigonal set, representing the ion CH_3^+, to one component of the double bond of ethylene converts the model shown in Figure 38 into the tangent-sphere representation of a non-classical carbonium ion whose valence-bond structure as shown below and in Figure 29 contains one three-centered carbon-carbon-carbon bond.



This three-centered bond is similar to the three-centered aluminum-carbon-aluminum bonds in the dimer of aluminum trimethyl and to the three-centered boron-boron-boron bonds in B_4Cl_4.

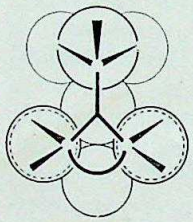


Figure 29. Tangent-sphere model of the non-classical carbonium ion $C_3H_7^+$. In the superimposed valence-bond diagram the three-centered carbon-carbon-carbon bond is indicated by three intersecting lines, which form an inverted "Y." In the literature this bond is usually indicated by a dashed triangle. Transition from this bridged structure to the classical structure $CH_3CH_2H_2^+$ can be visualized as occurring through a (perhaps solvent, S_N2-initiated) downward motion against the carbon-carbon two-centered bond (the bottom-most sphere) of the two protonated spheres of the methylene group on the right, or the one on the left. Formation of the secondary carbonium ion $CH_3CH^+CH_3$ from the primary carbonium ion $CH_3CH_2CH_2^+$ can be visualized as occurring in two steps of the type just described through the intermediate formation of a three-centered carbon-hydrogen-carbon bond.

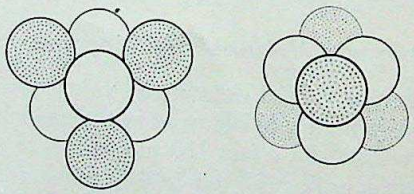


Figure 30. Two views of the bonding pairs in B_4Cl_4. The four stippled spheres represent two-centered boron-chlorine bonds, the four open spheres three-centered boron-boron-boron bonds. Each boron atom has in its valence shell four pairs: one boron-chlorine bond and three boron-boron-boron bonds. Not shown are the unshared pairs on the chlorine atoms.

The tangent-sphere representation of B_4Cl_4, excluding the lone pairs on the chlorine atoms, contains an inner tetrahedral set formed from four mutually tangent spheres. On each of the four trigonal faces of this tetrahedron rests another sphere (Fig. 30). Created in this way are four symmetrically placed tetrahedral holes. These holes contain the boron nuclei and their inner-shell electrons. The four outer spheres represent two-centered boron-chlorine bonds. The four inner

[2] A three-centered bond is an electron pair that is in the valence shell of three atoms.

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spheres represent three-centered boron-hydrogen-boron bonds.

Most of the known boron hydrides can be represented by tangent-sphere models. Figure 31 is an illustration of a symmetrical structure for the unknown compound B_9H_{15}. The presumed instability of this structure probably arises in part from the close approach to each other of the top three hydrogen atoms.

The tangent-sphere representation of lithium hydride is interesting to consider. It consists of a cubic-close-packed array of spheres, each sphere of which represents an electron pair and at whose center is a

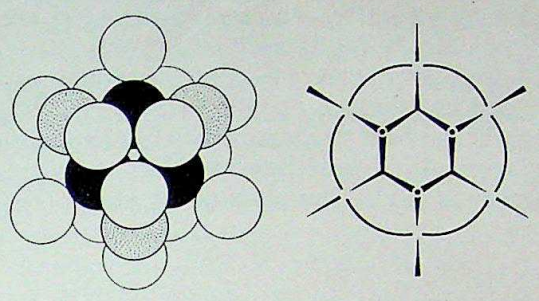


Figure 31. Tangent-sphere model and valence-bond diagram of a hypothetical structure for B_9H_{15}. Open spheres are protonated. The three at the top and the six outer ones at the bottom represent two-centered boron-hydrogen bonds; the six inner open spheres represent three-centered boron-hydrogen-boron bonds. Stippled spheres represent two-centered boron-boron bonds, black ones three-centered boron-boron-boron bonds. For a leading reference on the boron hydrides, see Hoffmann and Lipscomb, *J. Chem. Phys.*, 37, 2872 (1962).

proton. These protonated spheres represent the hydride ions. Surrounding each hydride ion are six lithium ions in the octahedral holes of the protonated electron-pair lattice.[3] The hydride ions represent, therefore, seven-centered lithium-lithium-lithium-lithium-lithium-lithium-hydrogen bonds. This result is not entirely surprising. Starting with the neon atom and moving to the left through the hydrides HF, H_2O, NH_3, CH_4, B_2H_6, and $(BeH_2)_n$, one finds that the number of electron pairs in one-centered orbitals (the unshared pairs) steadily decreases; the figures are, respectively, 4, 3, 2, 1, 0, 0, 0. The corresponding figures for the number of electron pairs per heavy atom in two- and three-centered orbitals are, respectively, 0, 1, 2, 3, 4, 2, 0 and 0, 0, 0, 0, 0, 1, 2. The trend seems clear. In moving toward lithium hydride increasing use is made of multicentered orbitals.

Alternatively, one may note that the core radius (0.60 Å) of lithium is much larger than the core radii of the other first-row elements (0.15, 0.11, 0.09, and 0.07, respectively, for carbon, nitrogen, oxygen, and fluorine (Pauling)). In this respect, lithium is like the second-row elements—particularly magnesium (core radius 0.65 Å)—where, so to speak, the valence-shell electrons touch the atomic cores before they touch each other and where, as a result, expanded octets are not uncommon. In the case of lithium, however, the formal charge on the atom would generally be excessive when its valence-shell contains six electron pairs unless, as in lithium hydride, these electrons are widely shared.

[3] Each Li^+ ion consists of a nucleus, charge $+3e$, and a $1s^2$ shell (not mentioned above) whose volume is about 3% of the volume of an H^- ion.

Electron Configuration About Atoms That Do Not Obey the Octet Rule

From the standpoint of the tangent-sphere model, the stereochemical features listed under "Gross Details" are an immediate consequence of the coordination by an atom of four localized electron pairs. The examples so far discussed all fall into this category. Figure 32 illustrates the useful fact that the tangent-sphere model can also be used to obtain the orbital configuration about atoms with electron-pair coordination numbers 1(H^-, He, Li^+), 2(BeH_2), 3(BH_3, CH_3^+, CH_2 (singlet state)), 5(PCl_5, SF_4, ClF_3, XeF_2, I_3^-), and 6 (SF_6, NSF_3, BrF_5, XeF_4, ICl_4^-).

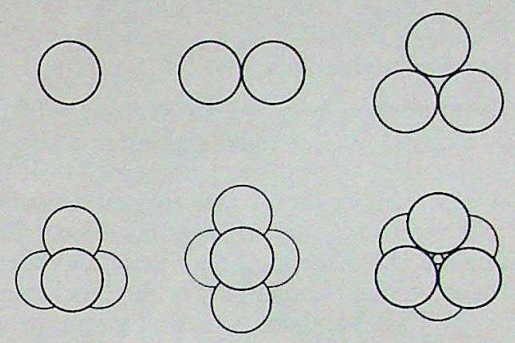


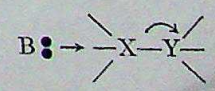
Figure 32. Summary of the stereochemistry about combined atoms for the electron-pair coordination numbers commonly encountered in practice. Coordination about an atomic core of one, two, three, four, five, or six localized electron pairs in the manner illustrated corresponds to the use, respectively, of the hybrid orbitals *s*, *sp*, sp^2, sp^3, dsp^3, or d^2sp^3.

Isoelectronic Molecules

The methane model, Figure 3 (Part I), may be thought of as representing also the electronic structure of ammonia and water. In the latter instances one or more of the valence-shell spheres would not be protonated. Calculations suggest that this does not greatly alter the effective size of a sphere (*16a*). Similarly, Figure 5 may be used to illustrate the electronic structures of ethane, methyl amine, methyl alcohol, methyl fluoride, hydrazine, hydroxyl amine, hydrogen peroxide, and so forth. It is interesting to note that the chlorine derivative of the recently reported (and probably planar) molecule XeF_4 (*24*) is isoelectronic with the well-known planar ion ICl_4^-. In the same sense, XeF_2 is equivalent to ICl_2^-.

Intermolecular Interactions

Inspection of the tangent-sphere models suggests that the interaction of an unshared pair on one molecule with the force field of a nucleus in another molecule should probably occur most readily off one of the external "pocket" sites in the second molecule. If the interaction between the attacking pair and the nucleus attacked is sufficiently strong, the nucleus may move from its normal position within its tetrahedral hole in the direction of the approaching lone pair on the nucleophilic reagent. This shift in nuclear position relative to the electron cloud of the system can be crudely summarized as follows.



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The models thus provide a concrete and perhaps not altogether imprecise picture in three dimensions of that branch of two-dimensional pencil-and-paper chemistry that for want of a better term is often referred to as "arrow bending" or "curly arrow chemistry." Pictured in Figure 33 is the tangent-sphere representation of a conventional S_N2 displacement reaction.

The same form of pair-pocket interaction can be used to account for such facts as the structure of crystalline iodine and the structures of the iodine complexes of amines, ethers, and ketones (*25*); the presence of linear chains in crystalline halogen cyanides; the occurrence in the halogen cyanides as well as in certain other molecular crystals of abnormally short intermolecular contacts; and the shapes of the ions I_5^-, Figure 34, and I_8^{2-} (*26*).

Intramolecular Interactions

Strong interaction between an electron pair and an adjacent internal pocket may lead after a simple nuclear displacement of the type mentioned to the formation of a new chemical bond with simultaneous rupture of an old one, i.e., to *trans*-elimination. Weaker interactions of the same kind may manifest themselves as lengthened vicinal bonds (*27*) or, if the vicinal bond is one of the C-H bonds of a methyl group, to an apparent tilt of the methyl group's symmetry axis toward the electron pair (*28*), with a concomitant increase in the corresponding valence angle. (In dimethyl ether, for example, the COC angle is greater than tetrahedral.) In orbital language this interaction may be described as the overlap of an electron pair with the internal lobe of the antibonding orbital of a *trans*-oriented vicinal bond.[4]

[4] These conclusions are supported by the recent suggestion of N. Muller and D. Carr (*J. Phys. Chem.*, 67, 112 (1963)) that the most important single parameter influencing the magnitude of the spin-spin coupling constants between ^{19}F and directly bonded ^{13}C nuclei is the "degree of double character" of the C—F bond.

Many of the facts of structural chemistry cited above can be demonstrated at the cost of only a few cents with 12 small spheres preassembled as a tetrahedral group (called below "4"), a digonal group ("2"), and two trigonal groups ("3", "3"). From these four vest pocket-sized components can be assembled—with the aid of appropriate valence-bond diagrams and a little manual dexterity—models of the tangent-sphere representations of the families of isoelectronic structures that contain such molecules as methane (4), ethane (4+3), propane (4+3+3), ethylene (4+2 or 3+3), carbon dioxide (3+3+2), carbon suboxide (3+3+2+4), propylene (4+2+3), *cis*-and *trans*-2-butene (4+2+3+3), acetone (4+2+3+3), acetylene (3+2), diacetylene (3+2+4), cyclopropane (4+3+2), cyclopropene (3+3+2), and cyclobutane (4+3+3+2). The 12-sphere kit can also be used to illustrate such things as the digonal, trigonal, trigonal bypyramidal, and octahedral arrangements of electron pairs about atoms (Fig. 32);

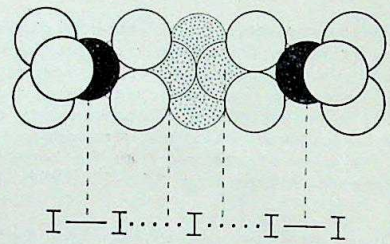

Figure 34. Tangent-sphere representation of the pentaiodide ion. As the formulation $I^-(I_2)_2$ for this ion suggest, I_5^- may be viewed as the interaction of an iodide ion with two iodine molecules: I-I···I⁻···I-I. The dotted lines in this formulation of the complex represent interactions between electron pairs in the valence shell of the iodide ion (the stippled spheres above) with the external pockets of the iodine molecules. The solid lines represent the original, now slightly weakened iodine-iodine bonds within the iodine ligands (the black spheres above). Two such pair-pocket interactions (···) on the same tetrahedral donor atom (I^-) produce a non-linear, v-shaped complex. It is pictured above as seen from the open edge of the "v." Similar considerations apply to the ion I_8^{2-}, whose modified valence-bond representation is I-I···I⁻···I-I···I⁻···I-I

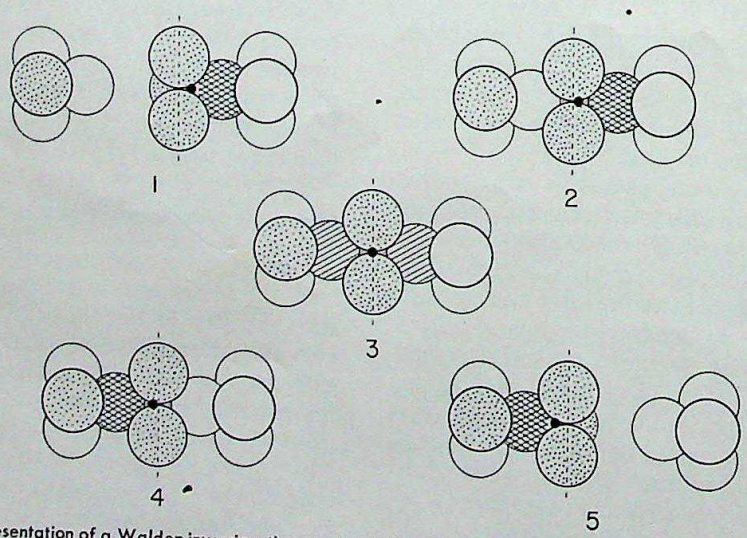

Figure 33. Tangent-sphere representation of a Walden inversion: the reaction $HO^- + H_3C—Cl = HO—CH_3 + Cl^-$. Stippled spheres represent O—H and C—H bonds, open spheres lone pairs. Cross-hatched spheres represent bonds between carbon and chlorine (stages 1 and 2) or carbon and oxygen (stages 4 and 5). The solid dot represents the carbon core. The dashed line through the methyl group indicates a plane through which the carbon core eventually passes. Stage 1: the reactants. Stage 2: backside attack on the methyl group by the hydroxide ion; the carbon core is beginning to move toward one of the previously unshared pairs on the oxygen atom. Stage 3: the transition state; this could also be a model of the triiodide ion, or of xenon difluoride. Stage 4: "mirror image" of stage 2; the carbon core is now more closely associated with the incoming pair on oxygen than with the outgoing pair on chlorine. Stage 5: the products.

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the equilibrium conformation of methyl groups adjacent to double bonds and the origin of the relatively low barrier to rotation in *cis*-2-butene (*20*); tilted methyl groups; and such simple but fundamental chemical reactions as borane plus ammonia, reversible hydration of olefins, the ring- and olefin-producing reactions of the carbonium ion $CH_3CH_2CH_2^+$ (*29*), and carbene insertion reactions.

The Hellmann-Feynman Theorem

A consideration of the electrostatic forces on atomic nuclei in molecules adds another dimension to the uses of the tangent-sphere models.

All forces on atomic nuclei in molecules can be considered as purely classical electrostatic attractions and repulsions involving Coulomb's law. The force on a nucleus, according to the Hellmann-Feynman theorem (*7*), is simply the electrostatic force that would be exerted on this nucleus by the other nuclei in the molecule and by the molecule's electron cloud considered as a classical charge cloud that is prevented from collapsing by obeying Schrödinger's equation (*7a*).[5]

To use the Hellmann-Feynman theorem it is not necessary to have a detailed knowledge of the wave function. A knowledge of the ordinary 3-space electron density function is sufficient. Today, of course, even this is not known with any great precision for most molecules of chemical interest. One might well question, therefore, the use in a qualitative sense (see below) of a theorem that, strictly speaking, applies rigorously only to a mathematically exact electron density function—which we do not have. The answer must be that our procedure is not the procedure of applied mathematics but the procedure of a growing science. Qualitative applications of the Hellmann-Feynman theorem, such as will be described below, do seem to fall into a consistent, and therefore in some senses, useful pattern. This fact established, one might hope thereby to be able in the future to progress further, step by step, toward a satisfying description of molecular structure.

Effect of Lone Pairs on Bond Angles

The angle between single bonds that meet at an atom with unshared electrons is generally less than tetrahedral, 107° in ammonia, for example, and 104.5° in water. This fact has been described by saying that lone pairs behave as *s*-seeking centers (*30*, *31*). Such behavior can be rationalized as follows.

The carbon nucleus in methane experiences no net electrostatic force upon it—due to repulsions of the protons and to attractions of the bonding pairs—when it is in the center of its tetrahedral hole. (Calculations (*16a*) suggest that nuclei of first-row elements can be assumed to be at the centers of their $1s^2$ shells, which in the present context may therefore be regarded as part of the nucleus.) In ammonia, however, the center of the tetrahedral hole—for simplicity we suppose here that all valence-shell spheres are the same size—is not a position of electrostatic equilibrium for the nitrogen nucleus. To reach such a position the nitrogen nucleus must move away from the protons toward the lone pair. In effect the nitrogen atom nucleus is pushed toward the lone pair by the hydrogen atom nuclei. This diminishes the H—N—H angle and requires that less *p* character and more *s* character be included in the description of the lone pair orbital if this orbital is to be described in terms of spherical harmonics centered at the nitrogen nucleus.[6]

Effect of Electronegative Groups on Bond Angles and Bond Lengths

Both bond angles and bond lengths are affected by electronegative groups. In compounds of the type A—B—C the length of bond A—B often decreases as the electronegativity of substituent C increases (*32*);

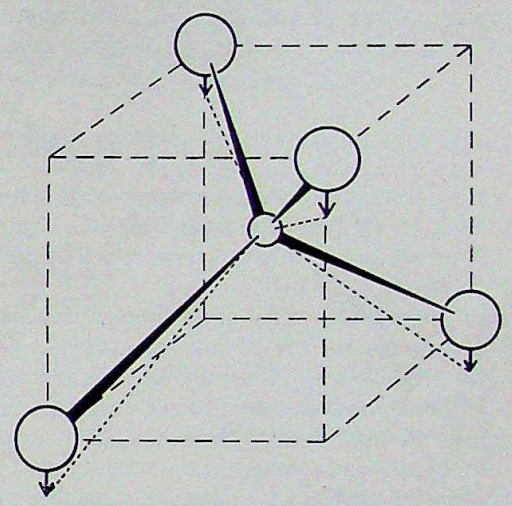

Figure 35. Summary of the displacement of the electron cloud about an atom relative to the atom's nucleus (the small sphere) when the electronegativity of the substituents bound by the two downward-pointing valencies increases. The central atom's *p* character in these two valencies increases and, correspondingly, its *p* character in the two upward-directed valencies decreases. In drawing this figure the assumption has been made that the radial function associated with a *p* orbital is not as contracted as that of an *s* orbital.

similarly, in compounds of the type AB_2 and AB_3 the valence angle BAB frequently decreases as the electronegativity of substituent B increases (*33*). These effects have been summarized in a rule that states that the *p* character of an atom tends to concentrate in orbitals that the atom uses in bonds toward electronegative groups (*30*, *31*). This rule is illustrated diagrammatically in Figure 35.

Figure 35 might represent, for example, the change in the electron cloud about an oxygen atom that occurs in going from OH_2 (bond angle 104.5°) to OF_2 (bond angle 103.8°). In this case the small sphere in the cube center represents the oxygen atom core, the two lower spheres represent bonding pairs of electrons (in either O—H or O—F bonds), and the two upper spheres represent the unshared pairs on the oxygen atom. In going from OH_2 to OF_2 the bonding pairs move away from the

[5] In the context of the tangent-sphere models, it may be noted that minimizing the energy of a molecule with respect to the nuclear positions holding constant the positions and radii of the tangent-spheres yields the Hellmann-Feynman theorem. Minimizing the energy with respect to the sphere radii holding constant the nuclear positions yields the virial theorem.

[6] Dr. Kimball has remarked that "In discussing bond angles [to such elements as carbon, nitrogen, and oxygen] it is an important fact that the core (including the 1s pair) is small enough to move within the 'hole' at the center of the tetrahedron without overlap. The motion of the core within the hole is the principal, but not the only motion, affecting the bond angle. The less important motions are displacements of the protons within their spheres, and changes in the radius of the valence electron spheres."

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oxygen nucleus and the angle subtended by them at the oxygen nucleus decreases; correspondingly the unshared pairs move in toward the oxygen nucleus and the angle subtended by them at the oxygen nucleus increases. The four arrows summarize the displacement of the electron cloud relative to the oxygen nucleus. The dotted lines indicate the new interorbital angles. If the wave function of a molecule can be satisfactorily expressed in terms of spherical harmonics centered at the nuclei, one may say that the change from OH_2 to OF_2 corresponds to shifting oxygen p character from the orbitals occupied by the lone pairs on oxygen to the bonding orbitals of the oxygen atom.

To this point, as well as in all other discussions of molecular structure based upon the use of atomic orbitals, the frame of reference adopted has been that of an observer standing at the location of an atomic nucleus and looking at the electron cloud about him from this fixed point. The tangent sphere model suggests a second frame of reference: the electron cloud itself.

From the point of view of an observer anchored to the electron cloud, the change in the position of the oxygen nucleus relative to the electron cloud when going from OH_2 to OF_2 can be represented in Figure 35 by a single arrow: one on the oxygen nucleus pointing upward.

A displacement of this kind seems reasonable. Electronegative atoms are atoms with large effective nuclear charges. These relatively unscreened charges exert on adjacent nuclei strong forces of repulsion that tend to drive the nuclei away from the electronegative atoms. Displacements resulting from these forces alter bond angles and bond lengths in a manner that is consistent in every respect with the previously cited rule regarding the distribution of atomic p character in molecules. Bond angles involving electronegative groups and bond lengths to substituents opposite electronegative groups will both tend to be smaller than normal, as is often observed.

Shapes of SF_4 and ClF_3

The sulfur-fluorine bonds in SF_4 are slightly shorter than the sum of the conventional covalent radii for sulfur and fluorine. It therefore seems reasonable to suppose that the sulfur-fluorine bonds in this molecule are conventional electron-pair bonds. This implies that the sulfur atom in SF_4 has an electron-pair coordination number of five (four pairs in bonds to fluorine and one pair unshared). The structure of this molecule has been determined recently by Tolles and Gwinn (*34*). Their results are given in Figure 36. The molecule can be considered to be a trigonal bipyramid in which one of the equatorial positions is occupied by a lone pair. The structure of this molecule appears to be consistent with the expectations of the tangent-sphere model.

Location of the lone pair at an equatorial position is reasonable since this places the "s-seeking pair" (*30, 31*) as close as possible to the sulfur nucleus.

The bonds to the axial fluorines (F_a) are slightly longer than those to the equatorial fluorines (F_e). This, too, is to be expected if the plausible assumption is made that the sulfur nucleus lies in the plane defined by the centers of the spheres that represent the equatorial electron pairs.[7]

That the actual ratio of bond lengths $(S—F)_{axial}/(S—F_{equatorial})$ is less than the calculated value is to be expected, also; for unlike the axial fluorine nuclei, which exert practically no net force on the sulfur nucleus, the equatorial fluorine nuclei exert a large resultant force on the sulfur nucleus in the direction of the lone pair. A displacement of the sulfur nucleus toward the lone pair would increase the axial-fluorine-sulfur distance less rapidly than the equatorial-fluorine-sulfur distance and would therefore diminish the value of the ratio of the first distance to the second. Such a displacement would also make the angle F_eSF_e less than 120°, as observed, and would cause the angle F_aSF_a to depart from 180° in the observed direction. Similar considerations apply to the molecule ClF_3, Figure 37.

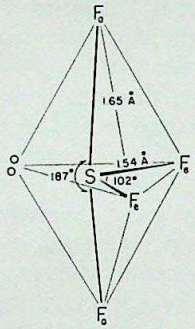

Figure 36. Structure of sulfur tetrafluoride (*34*).

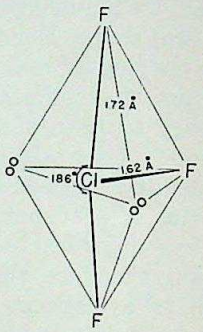

Figure 37. Structure of chlorine trifluoride.

Effect of Multiple Bonds on Bond Angles and Bond Lengths

The angle between two single bonds that meet at an atom bound by a double bond to another atom is generally greater than tetrahedral—118° for the adjacent C—H bonds in $H_2C=CH_2$, for example. Also, the length of the single bond from a substituent R to an atom X as a rule decreases as the remaining three bonds to atom X change from being all single bonds $(R—X\!\!<\!\!\!>)$ to one single bond and the components of a

[7] This analysis can be carried a step further. Insofar as the equal-sphere-size approximation for the valence-shell electron pairs of an atom is useful, one would expect the axial and equatorial bond lengths in SF_4, a molecule in which the central atom has an electron pair coordination number (EPCN) 5, to be, respectively, greater than and less than the S-F bond length in SF_6 (EPCN 6). The latter length is listed as 1.56–1.58 ± 0.02 Å. Thus, as expected,

$$(S - F_{axial})\text{EPCN } 5 > (S - F)\text{EPCN}6 > (S - F_{eq})\text{EPCN } 5$$

The difference between the first two is about 0.07 A. Similarly, the Xe-F bonds in linear XeF_2 (an EPCN 5 configuration that places the three unshared pairs in xenon's valence shell as close as possible to the xenon core—at the slight expense of the bonding pairs) are longer than the Xe-F bonds in XeF_4 (EPCN 6), again by about 0.07 Å. The experimental values recently reported for these Xe-F bond lengths are 2.00 Å in XeF_2 (Levy, H. A. and Agron, P. A. *J. Am. Chem. Soc.*, 85, 241 (1963)) and 1.93 Å in XeF_4 (Templeton, D. H., Zalkin, A., Forrester, J. D. and Williamson, S. M., *J. Am. Chem. Soc.*, 85, 242 (1963)).

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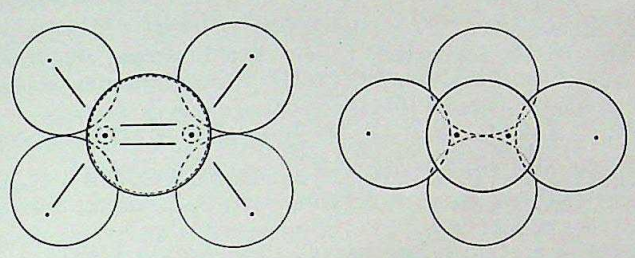
double bond (R—X<—) to the three components of a triple bond (R—X≡). The C—H bond lengths in ethane, ethylene, and acetylene, for example, are 1.114, 1.086, and 1.055 Å, respectively. These facts can be reconciled with each other in the following fashion.

The carbon-carbon internuclear distance decreases from 1.53 to 1.34 to 1.20 Å in going from ethane to ethylene to acetylene. Correspondingly the coulombic force of repulsion between the two carbon nuclei increases. In the molecules just cited this mutual repulsion tends to drive the carbon nuclei into their respective C—H bonds. This outward thrust tends to make the valence angle opposite a double bond greater than normal, Figure 38. At the same time it tends to



	CH_4	C_2H_4
HCH	109.5°	118°
C–H	1.095	1.086
J_{CH}	125	155
σ	0.00	0.36

Fig. 38

C–H	1.055
J_{CH}	248
σ	1.35

Fig. 39

Figure 38. Tangent-sphere model of ethylene. Small dots represent protons, larger dots carbon nuclei (small enclosing dashed circles represent 1s electrons). The carbon nuclei push each other toward the adjacent C—H bonds, with the results indicated. Straight lines illustrate the isomorphism that exists between a molecule's tangent-sphere model and valence-bond diagram.

Figure 39. Tangent-sphere model of acetylene showing the effect of the outward displacement of the carbon nuclei on several properties of the carbon-hydrogen bond (cf. Fig. 38).

make the corresponding C—H distance less than normal, the more so the closer the two carbon nuclei are to each other, Figures 38 and 39. Also, as the carbon-carbon internuclear distance decreases and the buttressing effect of one carbon nucleus on the other increases, the external C—H bonds are brought ever more under the influence of the carbon nuclei and the apparent electron-withdrawing power or inductive constant, σ, of the carbon atoms in these valencies increases (*35*) as does also the carbon(13)-proton coupling constant, J_{CH}, whose magnitude critically depends on the interaction between the electrons of the C—H bond and the carbon nucleus (*36*).[8]

This discussion also illustrates the appropriateness of a long-standing supposition (*37*); namely, that when describing the electron distribution in molecules in terms of spherical harmonics centered at atomic nuclei, it is proper to suppose that the radial function associated with an s-orbital is more contracted than that of the corresponding *p*-orbitals.

[8] The carbon-carbon spin-coupling constants reported recently by K. Frei and H. Bernstein (*J. Chem. Phys.*, **38**, 1216 (1963)) provide another illustration of the manner in which the properties of single bonds are influenced by the outward thrust of adjacent, multiply bonded carbon nuclei.

Mechanism of the Inductive Effect

The effect of electronegative substituents and multiple bonds on molecular structure can be summarized as follows. The location of atomic cores within their tetrahedral holes can be altered in two ways: by changing the nuclear charges on adjacent atoms (see section on "Effect of Electronegative Groups on Bond Angles and Lengths") or by changing the distances to adjacent atoms (see section on "Multiple Bonds). Taken together these two items provide a concrete picture of the inductive effect. Consider, for example, the molecular fragment R—C_1—C_2—C_3. As the electronegativity of substituent R increases, carbon-core C_1 is pushed toward carbon-core C_2; and as the distance between carbon-core C_1 and carbon-core C_2 decreases, carbon-core C_2 is pushed toward carbon-core C_3; etc. This description of the inductive effect is analogous in every detail to one given earlier by the author in which use was made of the rule concerning the distribution of atomic *p* character in molecules (*38*).

The Variable Effect of Multiple Bonds on Bond Lengths

The previous discussion provides an explanation for the curious fact that the change from a single bond to a double bond or from a double bond to a triple bond alters the length of an adjacent carbon-substituent bond relatively little when the substituent is hydrogen, somewhat more when the substituent is a methyl group, and still more when the substituent is chlorine (*31*, *39*). For as the carbon nucleus moves toward the substituent, the substituent will tend to ride further along the bond—corresponding to the picture of the inductive effect just cited—the larger the force constant of the carbon-substituent bond. One expects to find, therefore, an inverse correlation between the stretching force constant of a bond, which measures the resistance of the bond to changes in length, and the susceptibility of the bond to changes in length with a change in adjacent unsaturation. The larger the stretching force constant, the smaller should be the change in bond length. Typical stretching force constants for C—H, C—CH_3, and C—Cl bonds, are, respectively, 5.0, 4.5, and 3.4 millidynes/angstrom.

Conclusion

With the passage of time it seems likely that the discussion given above will prove to have only touched the surface of the possible applications of the tangent-sphere models.

Already it has been shown (*16a*, *b*) that with some simplifying assumptions regarding the nature of the charge distribution within each sphere—e.g., that it is uniform—it is possible to introduce Planck's constant into the treatment of complex molecules with a simplicity that exceeds and with an accuracy that rivals that of conventional, more complex treatments. Largely this is because the tangent-sphere treatment avoids the use of overlapping one-electron orbitals (*16*, Part I) and, hence, the very great and perhaps entirely artificial mathematical problems associated with exchange integrals (*9*, Part I).

On the other hand, the tangent-sphere treatment does partake of that part of current molecular orbital theory that is generally conceded to be sound: namely,

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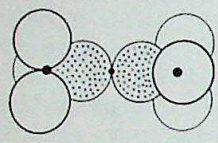
the requirement that the electron cloud be considered not as parts in isolation but as a whole. This happens quite automatically since the spheres by supposition are tangent to one another. Remove one of them and the shape of the set that remains, or the location of the atomic nuclei within the set, will generally change. The implications of this statement appear to be consistent with what is known about the shapes of radicals and of molecules in excited states.

Another feature of the model not discussed above concerns the role of charge correlation between electrons of two different spin sets. Probably always to a small extent and, following Linnett (*14*), perhaps sometimes to a large extent the centers of the Fermi holes of two spin-paired electrons will not be coincident. Some chemical implications of this extension of the model have been explored elsewhere (*40, 41*).

The qualitative features of the energetics of the model have been summarized by Strong (*19*): An assembly of atoms will be most stable when the electrons can be as large as possible, consistent with keeping electrons away from each other but close to the nuclei, while keeping the nuclei away from each other.

HF_2^-



F·····H·····F

Figure 40. Tangent-sphere model of the symmetrical hydrogen bond in HF_2^-. Large dots represent the fluorine cores. The small dot represents the proton.

Hydrogen bond formation (Fig. 40) has been described by Kimball (*18*). As the nuclear charge on the heavy atom increases in the sequence CH_4, NH_3, H_2O, HF, the protons are pushed closer to the surface of the shrinking electron pairs. Conversely, as the central nuclear charge decreases in the sequence NH_4^+, CH_4, BH_4^-, the protons approach the centers of their expanding electron pairs; these protonated pairs therefore become more hydridic and in the presence of sufficiently strong Lewis acids, such as Al^{3+} and BH_3, may be accepted, proton and all, into the valence shell of another atom, forming thereby, as in aluminum borohydride and diborane, protonated, three-centered bonds.

Many interesting problems, however, remain to be considered. Aromatic systems, for example, have been carefully ignored in the present discussion. Also, while one may agree that the models do work in some cases, it should be emphasized that it is not really known why they work as well as they seem to. In short, what has been described here is a model, not a chemical theory. Properly the models should be viewed as a supplement to, not a substitute for, quantum mechanics in an area where the latter has encountered severe computational problems. Perhaps some young reader of THIS JOURNAL may someday see how to achieve a happy union between these models of the experimental facts of structural chemistry and the underlying principles of theoretical chemistry.

Literature Cited

(22) EISTERT, B., *Z. Phys. Chemie*, **B 52**, 202 (1942); EBERHARDT, W. H., CRAWFORD, B., JR., AND LIPSCOMB, W. N., *J. Chem. Phys.*, **22**, 989 (1954); Longuet-Higgins, H. C., *Quart. Rev.*, **11**, 121 (1957).

(23) *Cf.* FATELEY, W. F., BENT, H. A., AND CRAWFORD, B., JR., *J. Chem. Phys.*, **31**, 204 (1959).

(24) CLAASSEN, H. H., SELIG, H., AND MALM, J. G., *J. Am. Chem. Soc.*, **84**, 3593 (1962); CHERNICK, C. L., ET AL., *Science*, **138**, 136 (1962).

(25) HASSEL, O., AND RØMMING, C., *Quart. Rev.*, **16**, 1 (1962).

(26) HAVINGA, E. E., AND WIEBENGA, E. H., *Recueil*, **78**, 724 (1959).

(27) BENT, H. A., *J. Chem. Phys.*, **36**, 1090 (1962).

(28) PIERCE, L., AND HAYASHI, M., *J. Chem. Phys.*, **35**, 479 (1961).

(29) SKELL, P. S., AND STARER, I., *J. Am. Chem. Soc.*, **84**, 3962 (1962).

(30) BENT, H. A., J. CHEM. EDUC., **37**, 616 (1960).

(31) BENT, H. A., *Chem. Rev.*, **61**, 275 (1961).

(32) BENT, H. A., *J. Chem. Phys.*, **33**, 1260 (1960).

(33) MELLISH, C. E., AND LINNETT, J. W., *Trans. Far. Soc.*, **50**, 657 (1954); WALSH, A. D., in "Progress in Stereochemistry," Vol. I, KLYNE, W., ed., Academic Press, Inc., New York, 1954, chap. 1.

(34) TOLLES, W. M., AND GWINN, W. D., *J. Chem. Phys.*, **36**, 1119 (1962).

(35) TAFT, R. W., JR., in "Steric Effects in Organic Chemistry," NEWMAN, M. S., ed., John Wiley and Sons, Inc., N. Y., 1956, chap. 13.

(36) MULLER, N., AND PRITCHARD, D. E., *J. Chem. Phys.*, **31**, 768 (1959).

(37) MULLIKEN, R. S., *J. Phys. Chem.*, **41**, 318 (1937); WALSH, A. D., *Disc. Far. Soc.*, **2**, 18 (1947); MOFFITT, W., *Proc. Roy. Soc. (Lond.)*, **A202**, 534 (1950).

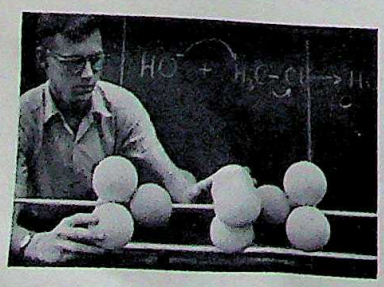
(38) BENT, H. A., *Can. J. Chem.*, **38**, 1235 (1960).

(39) BROWN, M. G., *Trans. Far. Soc.*, **55**, 694 (1959).

(40) BENT, H. A., *J. Inorg. Chem.*, **2**, 747 (1963).

(41) BENT, H. A., in "Organic Sulfur Compounds," KHARASCH, N., ed., Pergamon Press, N. Y., In press.

The cover



For an explanation of the model being held by Herbert Kirst, a sophomore chemistry major at the University of Minnesota, the reader is referred to stage 1 of Figure 33. The hydroxide ion on the reader's left and the components of methyl chloride on the reader's right can be moved along the horizontal dowel rod, which represents, in a sense, the reaction coordinate of the Walden inversion shown on the blackboard. The dowel rod passes through the center of the lone pair on the hydroxide ion that is attacking the CH_3—Cl bond and through the center of the sphere that represents the carbon-chlorine bond, or one lone pair of the displaced chloride ion. The dowel also passes through a hole in the center of a small triangular piece of wood that is glued into the trigonal hole of the methyl group, which is not glued or pegged to the C—Cl bond; in this way, the methyl group is kept properly oriented about the reaction coordinate.

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TLC—Versatile Tool

Chromatography using thin layers of adsorbents on glass plates (thin layer chromatography, TLC) has been the subject of a number of current reviews (*1–6*). This technique has gained wide recognition as a simple and rapid method for the fractionation, analysis, and isolation of a great variety of substances. Complex mixtures of amino acids, lipids, vitamins, dyes, drugs, and inorganic anions and cations—to give a few examples—may be separated by this method, and remarkable results are often obtained. This versatile technique, which is currently being used in industrial and research laboratories throughout the world, often supersedes in usefulness other important methods of chromatography.

The simplicity and speed of TLC, and the low cost of the necessary equipment, make it an ideal tool for teaching through classroom demonstrations and laboratory experiments. Furthermore, TLC—unlike more laborious and time-consuming methods of chromatography, such as column chromatography—may be used by students after a few minutes of instruction.

Apparatus and Techniques

Applicators and Other Equipment. Most separations using TLC are accomplished in less than one hour, and simple and inexpensive methods for preparing thin layer plates have been described by Wollish (*6*) and others. Bekersky (*7*), for example, obtained them by spraying a suspension of adsorbent on glass (8- × 8-in.) with an ordinary spray bottle. Peifer (*8*) reported a method for coating lantern slides, microscope slides, and even microscope cover slips with thin layers of adsorbents. Recently, several uses of microscope slides for the separation of complex mixtures have been described (*9,10*). These inexpensive methods for preparing thin layer plates do not give the highly uniform layers that may be obtained with the Stahl or other commercially available applicators (*3*), but they are perfectly adequate for most applications of TLC where the mixtures to be resolved are not highly complex.

Chromatography tanks may be obtained from commercial sources at nominal cost or may be made from ordinary laboratory equipment. A glass beaker, for example, covered with aluminum foil or a glass plate, serves as a readily available and inexpensive chromatojar. Furthermore, capillaries made from narrow gauge glass tubing may be used instead of commercially available pipets when the application of exact amounts is not required.

Coating Materials, Solvents, and Indicators. Almost any coating material used in column chromatography, with or without added binder, such as calcium sulfate, may be used for the preparation of thin layer plates. Silica gel, aluminum oxide, cellulose, carbon, and mixtures thereof have the widest application.

The most widely used solvents for TLC are petroleum hydrocarbons, diethyl ether, benzene, chloroform, methanol, water, and mixtures thereof.

Most indicators that have found application to paper chromatography are suitable for TLC. The following indicators are used extensively: water (for compounds that are immiscible with this solvent); iodine vapors; 2′7′-dichlorofluorescein in 95% ethanol-ultraviolet light; and sulfuric acid (50%) with charring. These indicators may be used individually or consecutively on the same plate.

Chromatographic Procedure. TLC is usually conducted as follows: the sample, dissolved in solvent, is applied about $^3/_4$ in. from the edge of the plate with a micropipet or capillary. The plate is then placed in a chromatography tank containing solvent. Rapid equilibration is obtained if one or two sides of the tank are lined with filter paper that extends into the solvent. After the solvent has reached a height of about 5 in., the plate is removed and the resolved components are usually revealed by a spray indicator.

Lecture Demonstrations

TLC, because of its speed and simplicity, makes a highly effective lecture demonstration. The thin layer chromatogram shown in Figure 1, for example, illustrates the separation of a mixture of dyes (100 mg; principally 4-dimethylamino-azobenzene, Sudan Red G, and indophenol) on silica gel. In this experiment, a series of spots was placed across one edge of the plate so that sufficient amounts of each separated component could be isolated in pure form. The chromatogram was developed by elution with 90:10 v/v of petroleum hydrocarbons (bp 30–60°)–ethyl acetate, which effected partial separation of the mixture after only 5 min.

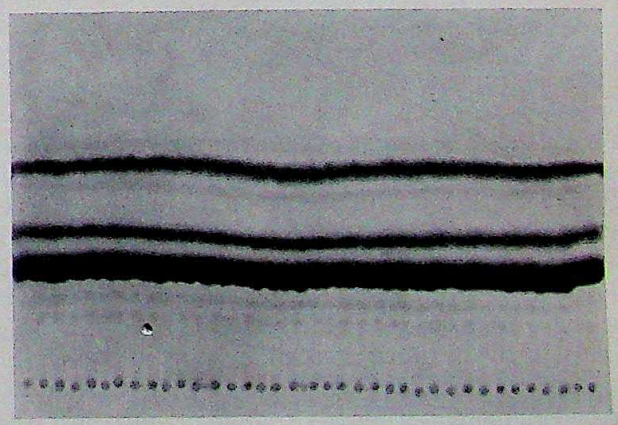

Figure 1. Preparative TLC, separation of a mixture of dyes: adsorbent, Silica Gel G; solvent, petroleum hydrocarbons (bp 30–60°)–ethyl acetate, 90:10 v/v; amount, 100 mg. From bottom to top: Sudan red G, 4-dimethylamino-azobenzene (blue), and indophenol (yellow).

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In one hour, the different colored bands were completely separated as shown in the figure. The dyes were then scraped off the plate with a razor blade and eluted from the adsorbent with chloroform. Each dye was obtained in pure form after evaporation of the solvent. This experiment, which provides a colorful demonstration of chromatographic methods of separation and recovery, was recently performed without difficulty by a first-year junior high school student.

Laboratory Experiments

TLC has proven to be highly successful for the separation of classes of compounds that migrate at different rates by virtue of their respective polarities, i.e., according to type and number of functional groups. As an example, the different migration rates of a variety of fatty acid derivatives, ranging in polarity from hydrocarbons to phospholipids, are illustrated in Figure. 2. Although subfractionations are sometimes perceptible, they do not usually interfere with separations according to class (*11*). It is noteworthy that the adsorption sequence of these aliphatic derivatives is comparable to that established by Brockmann (*12*) for aromatic compounds containing similar functional groups.

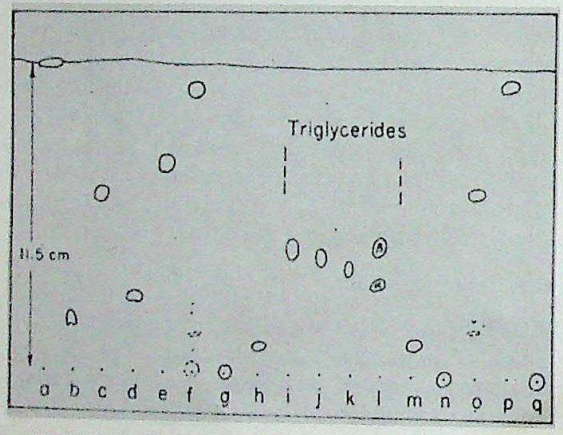

Figure 2. TLC of lipid classes: adsorbent, Silica Gel G; solvent, petroleum hydrocarbons (bp 30–60°)–diethyl ether–acetic acid, 90 : 10 : 1, v/v/v; indicator, 2', 7'-dichlorofluorescein, 0.2% in ethanol; amounts: 20γ, each. The letters correspond to compounds as follows: (a) 9-octadecene, (b) oleyl alcohol, (c) oleylaldehyde, (d) oleic acid, (e) methyl oleate, (f) cholesteryl oleate, (g) monoölein, (h) diolein, (i) triolein, (j) trilinolein, (k) trilinolenin, (l) tributyrin (α) plus tristearin (β), (m) cholesterol (n) selachyl alcohol, (o) chimyldiolein, (p) oleyl oleate, (q) dioleoyl lecithin—From Malins and Mangold (*11*).

The following simple experiment is recommended for use in high school and junior high school classes in science: a mixture of equal parts of castor oil, olive oil, and petroleum jelly is dissolved in diethyl ether and chromatographed together with standards on silica gel (Fig. 3). The components are revealed by spraying the chromatogram with 0.2% 2′,7′-dichlorofluorescein in ethanol (*13*). If, in addition, the plate is placed under an ultraviolet light, the spots will exhibit a vivid fluorescence. The chromatogram should be viewed for only a few moments through glasses to protect the eyes. The spots are also revealed by spraying the chromatogram with 50% sulfuric acid followed by *gently* heating the plate until charring occurs (*3*). Experiments may also be conducted on readily obtainable mixtures such as various naturally occurring oils (*13*), vegetable pigments (*9,14*), vitamin formulations (*3*), and ink pigments (*15*).

Organic Syntheses. In organic synthesis classes, the student is not only obliged to obtain a product but also to isolate it in relatively pure form and to determine its physical and chemical constants. If his reaction has not gone well, or if his yield is poor, he may not be aware of his predicament until he has spent several hours isolating and characterizing the product.

TLC can help solve these problems. This technique has been used for following the course of chemical reactions. Over prescribed intervals of time, for example, small aliquots of a reaction mixture may be removed and chromatographed on thin layer plates—often without prior removal of the solvent. This rapid procedure does not require the use of laborious time-consuming chemical analyses and eliminates the necessity for isolating intermediates, side-products, and products in the analysis of the reaction mixture. An excellent example of the use of TLC for monitoring chemical reactions was recently described by Gauglitz and Lehman (*16*), who determined the rate of conversion of triglycerides to alkyl esters in an alcoholysis reaction. The disappearance of the triglycerides and the simultaneous formation of the alkyl esters was graphically demonstrated by TLC (Fig. 4).

TLC is also highly effective for the isolation of small quantities (usually 10 to 100 mg) of compounds from crude reaction products. The use of this technique for preparative purposes not only saves the student time but also gives him a valuable working knowledge of the fundamentals of chromatography as well. In addition, TLC is a simple and direct method for obtaining very pure derivatives for elemental analyses, melting points, optical rotations, or other chemical and physical determinations.

Organic Analyses. Mixtures of organic unknowns are usually fractionated by their relative solubilities in different solvents. Other methods, such as acid-base washings, may then be used to further purify the resolved components. The pure compounds are finally characterized by their physical and chemical constants, or by the melting points of their derivatives.

Substances analyzed by TLC may be identified by the use of selective spray indicators (most indicators used in paper chromatography are applicable to TLC) (*6*). Resolved compounds may also be removed from

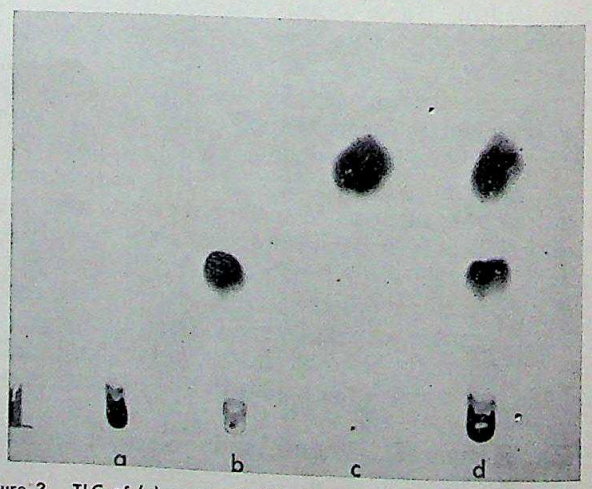

Figure 3. TLC of (a) castor oil, (b) olive oil, (c) petroleum jelly, and (d) mixture of (a), (b), and (c). Adsorbent, silica gel G; solvent, petroleum hydrocarbons (bp 30–60°)–diethyl ether, 85:15, v/v; Amount, 500 γ each spot; Indicator, 50% sulfuric acid, charring.

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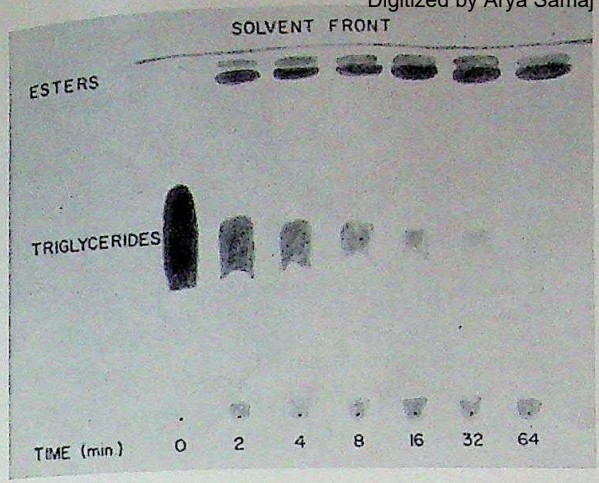

Figure 4. Thin layer chromatogram showing the conversion of mixed triglycerides to n-hexylesters in an alcoholysis reaction. Adsorbent, Silica Gel G, solvent: petroleum hydrocarbons (bp 30–60°)–diethyl ether, 90 : 10, v/v; indicator, saturated atmosphere of iodine vapors—from Gauglitz and Lehman (16).

the adsorbent and further analyzed by complementary methods. Sufficient amounts of compounds may usually be obtained by TLC for the determination of the usual physical (melting point and refractive index) and chemical constants (specific reactivity with various reagents) that are generally required to characterize a compound. TLC, therefore, may be used to great advantage in courses in organic analysis and may often serve to supplement, or even replace, traditional methods of separation, isolation, and identification.

Mixtures of low molecular weight volatile compounds may also be readily fractionated by TLC as their derivatives. Low molecular weight substances such as aldehydes, for example, have been fractionated as 2,4-dinitrophenylhydrazones (*17*) by this method, and so have mixtures of 2,4-dinitrophenyl derivatives of short-chain amines (*3*). These derivatives may be recovered from the adsorbent in 10–100 mg amounts as described previously, and their melting points may be determined without further purification. Using these techniques, the student would find that time-consuming crystallizations are unnecessary and that derivatives obtained in this way generally give sharp melting points and are free of contaminants.

General Applications

Several new applications of TLC have been reported recently. Reversed-phase partition TLC on siliconized silicic acid was found to be useful for the fractionation of compounds in homologous series. Fatty acids, for example, were fractionated by this method according to chain-lengths and degrees of unsaturation (*11*). Mercuric acetate adducts of long-chain unsaturated compounds were also readily separated according to degrees of unsaturation on silicic acid plates (*18*). Ionophoresis has been described by Honegger (*19*), who combined this innovation with two-dimensional TLC for the separation of amines and amino acids. Remarkable separations of complex mixtures of *cis*, *trans*, and positional isomers on thin-layers of silicic acid impregnated with silver nitrate have been reported by Barrett and co-workers (*20*). Most separations using TLC have been conducted on mixtures of organic compounds. This technique, however, has recently been used for the separation of inorganic compounds and also for the fractionation and identification of a variety of anions and cations (*21–25*).

One of the most rewarding applications of TLC is in analytical and preparative radiochemistry (*26–28*). Trace amounts of compounds have been detected and analyzed by using the isotopic derivative technique: i.e., the detection and analysis of components in mixtures after reaction of their functional groups with radioactively labeled reagents. TLC has also been applied to the determination of radiochemical purity of compounds prior to their use in metabolic studies. The isolation of highly pure radioactive compounds from crude synthetic preparations and complex biological mixtures has also been successfully undertaken by use of this method (*27*).

The use of the isotopic derivative technique in conjunction with TLC is demonstrated by the autoradiograph of ^{14}C-esters of castor oil fatty acids (Fig. 5) (*27*).

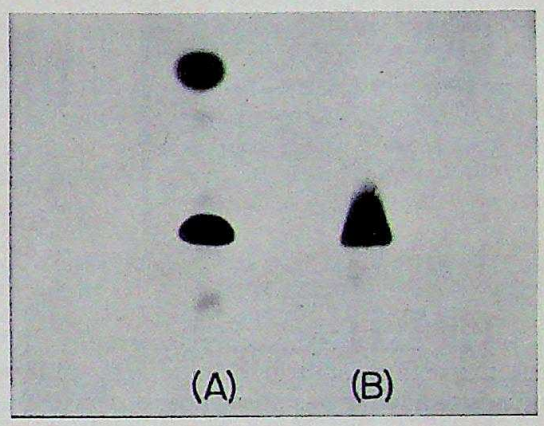

Figure 5. Autoradiograph of methyl-^{14}C-esters (A) and acetoxy-^{14}C-acids (B) from castor oil—from Mangold, Kammereck, and Malins (27).

In this experiment, a sample of the total fatty acids was esterified with radioactive diazomethane. Another sample was acetylated with radioactive acetic anhydride. The ratios of the different classes of acids were then evaluated by counting the respective activities of the ^{14}C-esters after their separation by TLC.

Because of its simplicity, speed, and versatility, TLC will become a highly valuable tool in the classroom and laboratory. About a thousand papers and three books (*29–31*) have been published on this method. Educational films on TLC have been prepared by Dr. O. S. Privett of the Hormel Institute, Austin, Minnesota, Dr. E. H. Ahrens, Jr., of the Rockefeller Institute, New York, and Dr. H. Seiler, Institut für Anorganische Chemie, Universität Basel, Basel, Switzerland.

Literature Cited

(1) Demole, J., *J. Chrom.*, **1**, 24–34 (1958).
(2) *Ibid.* **6**, 2–21 (1961).
(3) Mangold, H. K., *J. Am. Oil Chemists' Soc.*, **38**, 708–27 (1961).
(4) Stahl, E., *Angew. Chem.*, **73**, 646–54 (1961).
(5) Stahl, E., *Z. Analyt. Chem.*, **181**, 303–12 (1961).
(6) Wollish, E. G., Schmall, G. M., and Hawrylyshyn, M., *Anal. Chem.*, **33**, 1138–42 (1961).
(7) Bekersky, I., *Anal. Chem.*, **35**, 261–2 (1963).
(8) Peifer, J. J., *Mikrochim. Acta*, **3**, 529–40 (1962).
(9) Rollins, C., J. Chem. Educ., **40**, 32 (1963).
(10) Naff, M. B., and Naff, A. S., J. Chem. Educ., **40**, 434 (1963).
(11) Malins, D. C., and Mangold, H. K., *J. Am. Oil Chemists' Soc.*, **37**, 576–8 (1960).

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(12) Brockmann, H., *Discussions Faraday Soc.*, 1949, 58–64.
(13) Mangold, H. K., and Malins, D. C., *J. Am. Oil Chemists' Soc.*, **37**, 383–5 (1960).
(14) Anwar, M. H., J. Chem. Educ., **40**, 29–31 (1963).
(15) Druding, L. F., J. Chem. Educ., **40**, 436 (1963).
(16) Gauglitz, E., and Lehman, L., *J. Am. Oil Chemists' Soc.*, **40**, 197–8 (1963).
(17) Dhont, J. H., and DeRooy, C., *Analyst*, **86**, 74–76 (1961).
(18) Mangold, H. K., and Kammereck, R., *Chem. and Ind.*, 1032–3 (1961).
(19) Honegger, C. G., *Helv. Chim. Acta*, **44**, 173–9 (1961).
(20) Barrett, C. B., Dallas, M. S. J., and Padley, F. B., *Chem. and Ind.*, 1050–1 (1962).
(21) Seiler, H., and Seiler, M., *Helv. Chim. Acta*, **43**, 1939–41 (1960).
(22) *Ibid.*, **44**, 939–41 (1961).
(23) Seiler, H., and Rothweiler, W., *Helv. Chim. Acta*, **44**, 941–2 (1961).
(24) Seiler, H., and Gautenberger, T., *Helv. Chim. Acta*, **44**, 1282–3 (1961).
(25) Seiler, H., *Helv. Chim. Acta*, **44**, 1753–5 (1961).
(26) Mangold, H. K., *Fette Seifen Anstrichmittel*, **61**, 877–8 (1959).
(27) Mangold, H. K., Kammereck, R., and Malins, D. C., "Proceedings—1961 International Symposium on Microchemical Techniques," John Wiley and Sons, New York, 1962, Vol. 2, pp. 697–714.
(28) Snyder, F., and Stephens, N., *Anal. Biochem.*, **4**, 128–31 (1962).
(29) Randerath, K., "Dünnschicht-Chromatographie," Verlag Chemie, G.m.b.H., Weinheim, Germany, 1962.
(30) Stahl, E., Editor, "Dünnschicht-Chromatographie, Ein Laboratoriums-Handbuch," Springer-Verlag, Berlin-Göttingen, Heidelberg, Germany, 1962.
(31) Truter, E. V., "Thin Film Chromatography," Cleaver-Hume Press Ltd., London, 1963.

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TLC on Microscope Slides

An organic chemistry experiment

Thin layer chromatography (TLC), a micro method of adsorption chromatography, possesses distinct advantages over paper chromatography. Specifically, the separations are faster and the developed spots are sharper. With inorganic adsorbents it is possible to use detecting reagents which are destructive to paper, e.g., conc. sulfuric acid, basic permanganate, etc.[1] The following experiment illustrates the general utility of thin layer chromatography as a method of separation; all techniques commonly employed are introduced.

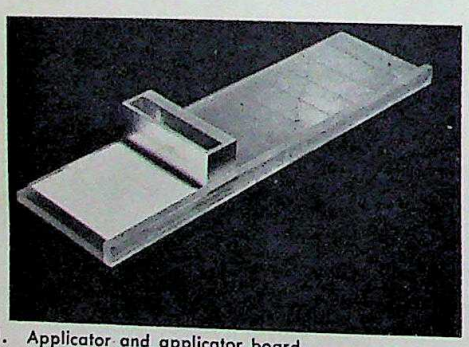

Figure 1. Applicator and applicator board.

The laboratory work consists of three short experiments: (1) Separation of three mixtures of dyes, the components of which are known, and an unknown dye mixture to identify; (2) Separation of a known mixture of seven phenols and an unknown phenol to identify; and (3) Separation of dyes and impurities present in each of three fluorescein dyes. It is advantageous to show at least one of the following films in the introduction of thin layer chromatography to a class:

"Thin Layer Chromatography" produced by E. H. Ahrens, Jr., Rockefeller Institute. Playing time: 10 minutes.

"Thin Layer Chromatography" produced by O. S. Privett, Hormel Institute. Playing time: 45 minutes. This film requires a Bell and Howell 302 Magnetic Sound Projector.

The essential pieces of equipment are an applicator and applicator board (see Fig. 1), a plastic ruling bar for channeling the plates, Peerless wooden applicator sticks[2] which are used as a substitute for micropipets, a 4 oz. developing jar[3] with a plastic cap, an all-glass spray bottle that delivers a fine mist, a short-wave ultraviolet light, and microscope slides. The applicator may be fashioned from a 3 in. length of 1 × 1-in. aluminum or plastic bar. The front edge is undercut 0.25 mm and machined uniformly. Plexiglas sheet, $^1/_4$-in. thick, is satisfactory for the construction of an applicator board.

All the chemicals were Eastman white label except as noted. The dyes and phenols are listed in the table. In the preparation of solutions methanol was used as the solvent. The known phenol solution[4] contained 3% of each of the seven different phenols; and the unknown solution, 1% of the phenol. All other solutions were 0.1% with respect to each dye, except rhodamine B, which was 0.05% and Sudan IV, which was 0.03%. It was necessary to dissolve Sudan IV in hot methanol.

The Experiment

Eleven slides were aligned on the applicator board.

[1] Stahl, E., "Dunnschicht-Chromatographie," Springer, Berlin, 1962; English edition, Academic Press, in press.

[2] Ganis, F. M., and Stotz, E. H., ACS Abstracts, Sept., 1962, p. 13F.

[3] The jar measured $2^1/_8$-in. diameter x $3^1/_4$-in. high, No. 10375, Central Scientific, Chicago, Illinois.

[4] Stable for 24 hrs.

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Results of Separations on Silica Gel Coated Microscope Slides

	Color	R_f	Direct light R_f	UV light R_f
Known mixture I				
Fluorescein	yellow	0.85		
Rhodamine B[a]	red	0.43		
Malachite green	green	0.12		
Known mixture II				
Sudan yellow[a]	orange	0.83		
Crystal violet[a]	violet	0.20		
Methylene blue[b]	blue	0.02		
Known mixture III				
Sudan IV[c]	red-brown	0.83		
o-Cresolsulphone-phthalein	yellow	0.65		
Victoria blue[a]	blue-gray	0.30		
		0.00		
Developing solvent: methyl ethyl ketone, acetic acid, isopropyl alcohol 2:2:1				
Developing time: 20 min				
Phenols				
o-Nitrophenol		0.73		
o-Phenylphenol		0.60		
m-Cresol		0.53		
m-Nitrophenol		0.45		
o-Hydroxybenz-aldehyde		0.30		
Resorcinol[d]		0.23		
Phloroglucinol[d]		0.07		
Developing solvent: toluene, dioxane 50:8				
Developing time: 10 min				
Fluorescein dyes				
Fluorescein[d]				0.47
			0.27	0.27
			(yellow)	0.00
Dichlorofluorescein				0.67
			0.50	0.50
			(orange)	0.40
				0.26
Tetrabromo-fluorescein[e]			0.75	0.75
			(pink)	0.67
			0.67	0.60
			(pink)	0.27
Developing solvent: toluene, acetic acid 65:35				
Developing time: 10 min				

[a] National Aniline Division of Allied Chemical, New York, N. Y. [b] J. T. Baker Chemical Co., Phillipsburg, N. J. [c] Fisher Scientific Co., Pittsburgh, Penna. [d] Eastman Kodak, practical, Rochester, N. Y. [e] Hartman-Leddon Co., Philadelphia, Penna.

Five ml of water and 2.5 g Brockmann silica gel G[5] were mixed thoroughly. This mixture was applied to the slides with the applicator. The coated slides were activated for 10 min at 105°. To mark the solvent front, a heavy line was drawn $^1/_2$ cm from the top of the plate; 6 cm below this line the starting points were marked lightly and spaced according to the number of spots to be developed on the slide. By channeling the coated slides, it was possible to separate four different mixtures on one slide.

Four ml of the developing solvent were placed in the jar. The composition of the solvent systems is listed in Table 1. To saturate the atmosphere in the container, the jar was capped and swirled vigorously for approximately 20 sec. The spotted plate was lowered carefully into the solvent and the jar capped. When the solvent reached the 6 cm mark, the plate was removed from the container and air-dried at least 10 min. The intrinsic color of the dyes makes the developed spots visible. After developing and air-drying, the phenol plate was sprayed lightly with 0.1% solution of 2′7′-dichlorofluorescein in methanol.[6] Under ultraviolet light the phenols appeared as purple spots on a lavender or fluorescent yellow background. The developed fluorescein dye plate was dried 10 min at 105° then viewed in direct light and under ultraviolet light. Heating the developed plate intensified the fluorescence of the spots. The distance traveled by each component was measured and the R_f value calculated.

The R_f values determined for the dyes, phenols, and fluoresceins are summarized in Table 1. A tracing of each separation is shown in Figure 2. The dichlorofluorescein and tetrabromofluorescein dyes each contain impurities which probably are unreacted fluorescein and the corresponding mono-, di-, tri-, or tetrahalogenated fluorescein.

Separations on these coated slides are characterized by the same degree of sharpness obtained with larger chromatoplates. Since the R_f values determined by thin layer chromatography are not entirely reproducible, it is essential to run a known mixture and an unknown on the same plate. Saturation of the atmosphere in the developing chamber, prior to developing the plate, reduces the developing time and improves the quality of the spots.

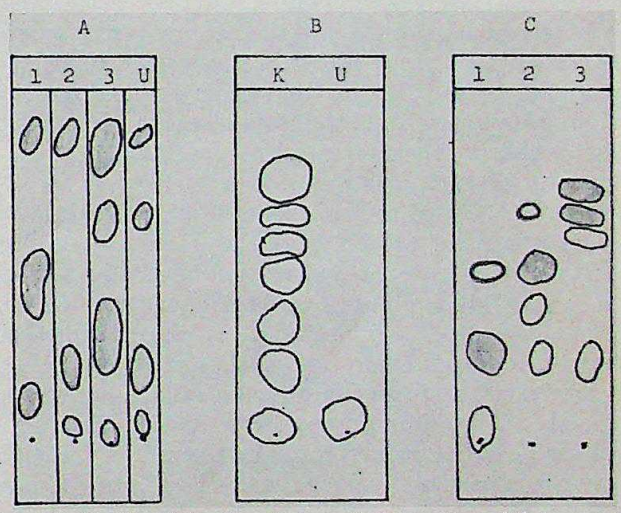

Figure 2. Tracing of developed chromatoplates *Dyes*, (*A*), known mixtures 1, 2, 3, and unknown—from bottom to top the colors are: blue, violet, yellow, and orange. The components of the unknown are: methylene blue, crystal violet, o-cresolsulphonephthalein, and Sudan yellow, *Phenols*, (*B*), known mixture and unknown-phloroglucinol. *Fluorescein dyes*, (*C*), (1) Fluorescein, (2) Dichlorofluorescein, (3) Tetrabromofluorescein (Eosin Y). The shaded spots are visible in direct light while the circles represent spots visible only under ultraviolet light.

In practice thin layer chromatography on coated microscope slides is a rapid method for following the course and, qualitatively, the rate of a number of organic reactions, e.g., esterification of an alcohol, ammonolysis of an ester, and nitration of aromatic compounds. This technique is especially useful in determining optimum conditions for separating compounds by column chromatography.[7,8] A solution of 0.1% 2′7′-dichlorofluorescein in methanol is a general reagent for detecting aromatic compounds.

[5] Brinkmann Instruments Inc., Great Neck, New York.

[6] A commercial aerosol container of the reagent was unsatisfactory, because the spray was too coarse.

[7] Duncan, G. R., *J. Chromatog.*, 8, 37 (1962).

[8] Miller, J. M., and Kirchner, J. G., *Anal. Chem.*, 24, 1480 (1952).

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TLC Separation of Ink Pigments

Separation of pigments of writing inks by the thin layer chromatographic techniques was used quite successfully as a student laboratory exercise and as a rapid lecture demonstration of this recently developed analytical separation method. The experiment is an adaptation of a paper chromatographic separation described in Reilly and Sawyer.[1] In our experiment, a thin layer of activated silica gel on a glass plate was used as the absorber, and ethanol was used as the solvent. The inks chosen for this demonstration were four of the Sheaffer's "Script" "washable" writing fluids, black, blue, green, and purple. In addition to the visible pigments, the manufacturer advertises the presence of "RC-35," a fluorescent ingredient which makes it possible to determine the original inscription in case of erasure.

The separation of inks into their component pigments was chosen for its simplicity in illustrating techniques and choice of solvents for thin layer chromatography; and, in addition, affords the student the opportunity to visually observe the course of the separation.

One ml of each ink was added to five ml of 95% ethanol. 5λ (0.005 ml.) of this solution was applied to the coated plate. If quantities as large as one drop are used, it is suggested that the ink be diluted further.

A series of glass plates, 1 in. × 8 in. were coated with silica gel by one of two methods. In the first method, a homemade applicator was used. This was an aluminum trough sliding on aluminum rails mounted to a flat slab. The aluminum rails were slightly thicker than the glass plates used and were spaced so that eight plates could be coated at one time. To 10 g of Kieselgel (Arthur H. Thomas, Philadelphia, Pa.) was added 23 ml of water, and the mixture stirred until thoroughly dispersed. This slurry was poured into the trough and the trough was drawn over the plates.

The second method of coating followed the procedure given by Bekersky[2] where the absorber was sprayed onto the plates. This resulted in plates of more uniform coating, and furthermore, allowed the students to study as laboratory exercise the effect of layer thickness on the degree of separation. To spray the silica gel slurry on the plates, either a Fisher atomizer (Fisher Scientific Co., New York) or a dentist's oral atomizer (L. D. Caulk Co., Newark, N. J., or any dental supply company) was attached to a small compressor or a nitrogen cylinder set at 10 psi. Best results were obtained when 10 g of Keiselgel were mixed with 30 ml of water. The plates were placed on a flat surface, and the atomizer held approximately 12–18 in. from the plate while coating. One slow pass with the sprayer provided a coating equal to the conventional applicator.

After the silica gel was applied, the plates were left in position for 10–15 min for the silica gel to set. The plates were then activated by drying in an oven at 110°C for 1 hr. Until use, the activated plates were stored in a desiccator over calcium sulfate.

Five lambda (0.005 ml) of the ink solution was applied to a plate 1.5 cm from the bottom, and a line was inscribed on the plate 10 cm above the uppermost edge of the spot. The plate was then placed in a 250 ml cylinder containing about 5–10 ml of 95% ethanol, and the cylinder was stoppered.

Solvent rise was quite rapid, and separation of the components of the ink was immediately noticeable. By shining an ultraviolet light on the plate, separation of the ultraviolet constituent could also be observed. When the solvent front had reached the 10 cm line, the plate was removed from the cylinder and air dried. The distance traveled by each component was measured and the values of R_f calculated. No attempt was made to determine the chemical composition of each constituent; however, by using the black ink, and a variety of solvents, the effect of changing solvent polarity on the degree of separation was investigated in the student laboratory. The table shows the results obtained for four colors of ink with 95% ethanol used as the solvent, for it appeared to give the best separation in the shortest time. In trying other solvent systems, it was found that the silica gel plates could tolerate up to 20% water in the solvent; beyond this, the thin layer would flake off the plate. Best separations were achieved by polar, water-like solvents, while non-polar solvents gave zero values for R_f.

R_f Values for Constituents of "Script" "Washable" Writing Fluids on Silica Gel Plates, Ethanol Solvent

Ink	Constituent	R_f	Comments
Black	"RC-35"	0.96	.....
	Yellow	0.94	Narrow band
	Red	0.92	.....
	Blue	0.80	Wide band
Blue	"RC-35"	0.93	.....
	Blue	0.92	Trace amount
	Dark Blue	0.85	Relatively narrow band
	Blue	0.00	Trace amount
Green	"RC-35"	0.95	.....
	Yellow	0.93	.....
	Blue	0.78	.....
Purple[a]	Blue	0.85	Very narrow band
	Red	0.84	Narrow band
	Purple	0.74	Wide band
	Dark blue	0.00	Trace amount

[a] Although the ink itself fluoresced under an ultraviolet light, no trace of an ultraviolet constituent could be found for this particular sample on the chromatographic plates.

[1] Reilly, C. N., and Sawyer, D. T., "Experiments for Instrumental Analysis," McGraw-Hill, New York, 1961, pp. 241–244.
[2] Bekersky, I., *Anal. Chem.*, 35, 261 (1963).

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Electrophoretic Study of Synthetic Food Dyes

At the present time the United States Government allows eleven synthetic dyes to be used in food products. Many papers dealing with the separation of these dyes and the study of their impurities have been published in the last decade. The majority of these works have examined paper chromatography as a technique of separating simple dye mixtures (*10, 13*) and of identifying colored impurities in individual dyes (*2, 3*). A few attempts have been made to separate simple dye mixtures by column chromatography using alumina as the adsorbent (*5, 7*). A characteristic of almost all of these papers is the multiplicity of solvent systems employed.

Some early work had been done to separate simple dye mixtures electrophoretically (*3, 6, 11, 12*). The use of paper, however, as a supporting medium in these experiments proved to be unsuccessful. In the paper by Šramek (*9*) the chromatographic behavior of disperse dyes is studied in relation to their molecular configuration. A study of the electrophoretic behavior of food dyes from this point of view afforded an excellent student project. Our work includes a study of the effect of charge density and mass of dye molecules on their mobility in an electric field.

The experiments were performed in a simple electrophoresis apparatus, using cellulose acetate membrane as the supporting medium. This membrane has previously been employed with success in the electrophoretic separation of proteins and amino acids (*1, 4, 8*).

We were able to separate the components of complex mixtures of food dyes with one buffer system. Depending upon the number of dyes involved and their chemical structure, a complete run took from a few minutes to less than 2 hr. Complete separation of as many as seven dyes was accomplished on a 5-in. strip in 1 hr.

The apparatus constructed for the experiment was a simple electrophoresis cell, consisting of two large (200 ml capacity) shallow Plexiglas containers and two similar containers half as large (Fig. 1). Notches were cut along the tops of the narrow sides of the large containers so that glass rods could be laid across them at varying distances. Across these parallel rods were stretched the cellulose acetate strips with steel clips at each end to prevent sagging. Into each smaller container was placed a carbon rod, electrically connected to a power supply consisting of three 90-v dry cell batteries. Each small container was, in turn, connected to one of the large ones by means of cotton wicks enclosed in glass tubing. The cover was dome-shaped in order to cause condensed droplets to move to the sides and prevent them from falling on the strip. The buffer solution used in the experiments consisted of equal parts of 0.1 *M* sodium acetate and isopropyl alcohol adjusted to *p*H 4.6 with acetic acid.

The experiment was conducted in the following manner: The containers were all filled to two-thirds of their capacity with the buffer solution. The cellulose acetate strip, cut to proper size, was thoroughly wetted with the buffer. Excess liquid was removed by pressing the strip between two pieces of absorbent paper. The dye mixture in solution was spotted approximately an inch from the midpoint of the strip with a capillary or a micropipet, and the weights were attached at each end. The current was then turned on, and the strip was laid across the properly spaced glass rods in such a manner that the dye mixture was closer to the cathode than to the anode. The cover was then put in place, and the experiment was timed.

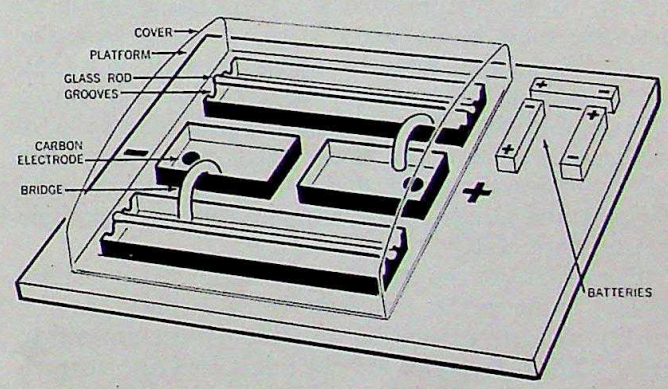

Figure 1. Electrophoresis apparatus.

When a charged ion is subjected to an electric field, it migrates toward one of the electrodes. The velocity of this movement depends upon the magnitude of charge and structure of the ion and upon certain factors in its surroundings. These environmental factors include concentration and *p*H of the buffer solution, applied potential, chemical, and physical characteristics of the supporting medium, and temperature and viscosity of the buffer. If the environmental factors are strictly controlled, the rate at which an ion migrates depends only upon the properties of the ion itself.

All eleven of the food dyes approved by the United States Government are sodium salts which, in an aqueous solution, dissociate into the sodium ion and the dye anion. The latter carries a net negative charge. The magnitude of the charge depends on the number of dissociable sodium ions in the dye molecule.

[1] Address reprint requests to Dr. Anwar at 40 Hickory Hill Road, Tappan, New York.
[2] See THIS JOURNAL, 40, 29 (1963) for the report of another investigation by members of the Community Resources Pool.

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It was found that, under applied potential, the velocity of migration is greater for dye acids which have a higher net charge. Also, among dyes which have the same charge, the speed of migration decreases as the molecular weight increases. Thus, if all eleven dyes are classified into groups of trisodium, disodium, and monosodium salts, and the members of each group are listed in the order of increasing molecular weight (Table 1), the resulting pattern conforms with the sequence of zones produced by the electrophoretic separation of the dyes (Fig. 2).

Table 1. Dyes Grouped According to Number of Dissociable Sodium Ions and Increasing Molecular Weight in Each Group

Official name	Classification	Dissociable sodium ions	Molecular weight
FD&C Yellow no. 5	Pyrazolone	3	534
FD&C Red no. 2	Monoazo	3	604
FD&C Yellow no. 6	Monoazo	2	452
FD&C Blue no. 2	Indigoid	2	466
FD&C Red no. 4	Monoazo	2	480
FD&C Green no. 2	Triphenylmethane	2	792
FD&C Blue no. 1	Triphenylmethane	2	792
FD&C Green no. 3	Triphenylmethane	2	808
FD&C Red no. 3	Xanthene	2	898
FD&C Green no. 1	Triphenylmethane	1	690
FD&C Violet no. 1	Triphenylmethane	1	733

Two of the dyes (Green 3 and Red 3) do not seem to fit this rule. Red 3 remains practically at the starting point. Green 3, although it has a greater molecular weight than Blue 1 or Green 2, moves ahead of these two dyes. We suspect that, even though Green 3 has a higher molecular weight than either of these two isomeric dyes, the presence of a hydroxyl group in its molecule could be the cause of this discrepancy. The immobility of Red 3 can be explained by the fact that, at the *p*H of our normally used buffer, this dye is so insoluble that it hardly moves from the point of applications. However, if the *p*H is raised above 6.0, this dye migrates ahead of the two monosodium dyes, Violet 1 and Green 2, and occupies its proper position on the membrane.

The dyes of the triphenylmethane group exhibit several noteworthy characteristics. They oxidize readily and are susceptible to fading when exposed to light. These problems may be minimized if the experiment is conducted in the dark under an inert atmosphere. This group also seems to possess the largest number of subsidiary dyes, some containing as many as four. We are currently investigating the problem of impurities in these dyes.

Paper was found to be an unsatisfactory supporting medium. It has a strong adsorptive power which causes tailing during separation. Cellulose acetate membrane, however, proved to be an excellent medium. It has uniform porosity and, due to the loss of most of its hydrophilic groups during processing, it has minimal adsorptive power. This eliminated tailing in our experiment.

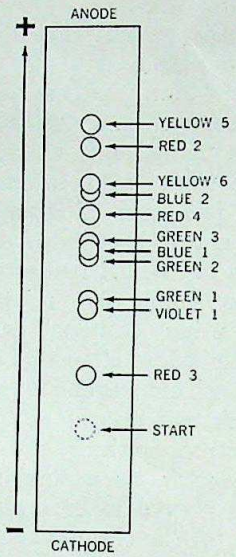

Figure 2. Electrophoretic pattern of eleven food dyes on cellulose acetate membrane.

Literature Cited

(1) Brackenridge, C. J., *Anal. Chem.*, **32**, 1353 (1960).
(2) Dolinsky, M., *J. Assoc. Offic. Agri. Chemists*, **37**, 805 (1954).
(3) Grassman, B. W., and Hubner, L., *Leder*, **5**, 49 (1954).
(4) Grunbaum, B. W., *Anal. Chem.*, **33**, 860 (1961).
(5) McKeown, G. G., and Thomson, J. L., *J. Assoc. Offic. Agri. Chemists*, **37**, 917 (1954).
(6) Mitra, S. N., and Chatterji, R. K., *J. Proc. Inst. Chemists, India*, **27**, 169 (1955).
(7) Mottier, M., and Potterat, M., *Anal. Chim. Acta*, **13**, 46 (1955).
(8) Scherr, G. H., *Anal. Chem.*, **34**, 777 (1962).
(9) Šramek, J., *J. Chromatog.*, **9**, 476 (1962).
(10) Tilden, D. H., *J. Assoc. Offic. Agri. Chemists*, **37**, 812 (1954).
(11) Werum, L. N., Gordon, H. T., and Thronburg, W., *J. Chromatog.*, **3**, 125 (1960).
(12) Yamaguchi, K., et. al., *J. Pharm. Soc. Japan*, **74**, 1322 (1954).
(13) Yanuka, Y., et al., *Analyst*, **87**, 791 (1962).

Two Chem Gems

The professor was more imaginative than absent-minded who was heard to mumble, "A 24-molar solution!" as his complete denture fell into the aqua regia.

The modern-day alchemist wonders if it may be possible to fuse two nuclei of element 72 into one of element 67. After all, what else can two halves make?

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A Gas Chromatography Demonstration Apparatus

An inexpensive apparatus for the separation of volatile organic compounds by gas chromatography has been described,[1] in which hydrogen was used as the carrier gas. The gas was burned as it emerged from the apparatus and the detection of components was accomplished by studying visual changes in the nature and height of the flame. For the purpose of class demonstration of gas chromatography it is necessary to use hydrogen under a pressure of 2–3 lb/sq in. in order to get a flame which is long enough to be visible. This introduces a hazard as the serum cap may be blown off and the pressure hydrogen become ignited by the burning emergent gas. These dificulities with respect to flame height and fire hazard have been overcome by modifying the technique so that hydrogen is replaced by oxygen or air as carrier gas and the emergent gas is led into a coal gas flame which may have a height of 2 to 3 in.

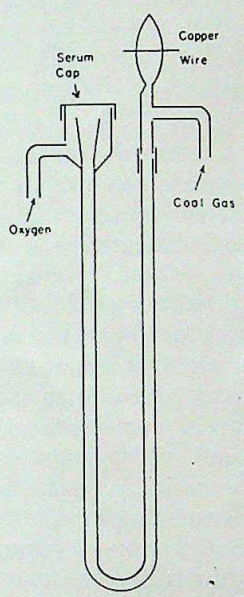

Figure 1. Diagram of the apparatus.

A convenient mixture for demonstration purposes is one containing chlorinated hydrocarbons which can be detected readily by means of a copper wire suspended in the coal gas flame.

The apparatus consists essentially of a Pyrex U-tube (30 in. in length; 6.5 mm id; 8.5 mm od). The carrier gas and coal gas inlets are arranged as shown in Figure 1.

The U-tube was packed with Celite (80–120 mesh) which had previously been treated with silicone oil as partitioner. The coal gas was ignited at the emergent orifice to give a luminous flame 2- -3-in. high. Oxygen at a pressure of 3 lb/sq in. or air at a slightly higher pressure was then passed through the apparatus; and if the coal gas flame remained luminous, the coal gas supply was adjusted accordingly. The sample (0.02 ml) which consisted of a ternary mixture of ethyl chloride, methylene chloride, and chloroform in the volume ratio of 1:1:1, was introduced via the serum cap by means of a hypodermic syringe. When one of these components appeared in the emergent gas, it imparted a green color to the flame as a result of the volatility of the copper halide formed on the copper wire detector.

When the apparatus was operated at ambient temperature (approximately 14°C) ethyl chloride appeared in the emergent stream after 45 sec, the flame coloration reaching a maximum after an additional 12 sec and finally disappearing after a further 12 sec. Methylene chloride appeared after the lapse of 100 sec from the time of introduction of the sample and burned for a total period of 50 sec while chloroform appeared after 250 sec and burned for 50 sec.

Besides offering a safe and easily visible demonstration of the separation of organic liquids by gas chromatography, the apparatus lends itself to the drawing of curves in which time is plotted against the intensity of the flame luminosity. By conducting the experiment in a semidark room and by focusing the copper halide flame on a Weston Master III universal exposure meter by means of a lens, the graph shown in Figure 2 was obtained for the ternary mixture above using compressed air at a pressure of 6 lb/sq in. as carrier gas.

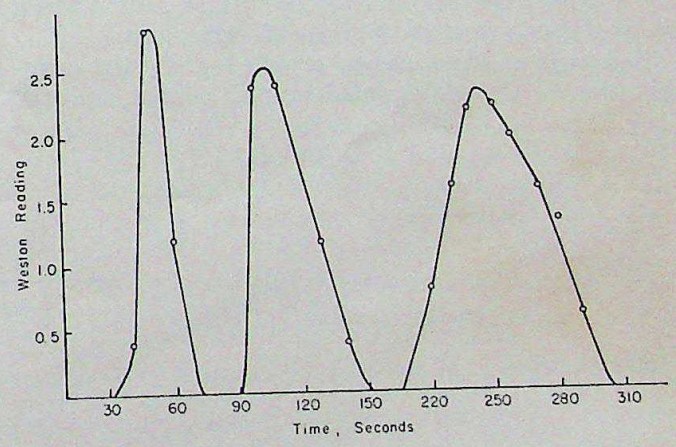

Figure 2. Intensity of flame luminosity versus time for a ternary mixture

Impressed by the success of the above separation we directed our attention to experiments of a semiquantitative nature. In these, the Celite column was

[1] Cowan, P. J., and Sugihara, J. M., J. Chem. Educ., 36, 246 (1959).

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inserted in the air stream leading to the photometer as in Figure 3 and readings were taken on the galvanometer at 10 sec intervals. Using mixtures of chloroform and methylene chloride in varying proportions and a copper wire detector, the galvanometer deflections were plotted against time; and it was shown that the ratio of the areas under the curves is the same as the ratio of the total chlorine content in the individual components of the mixture—see Table 1.

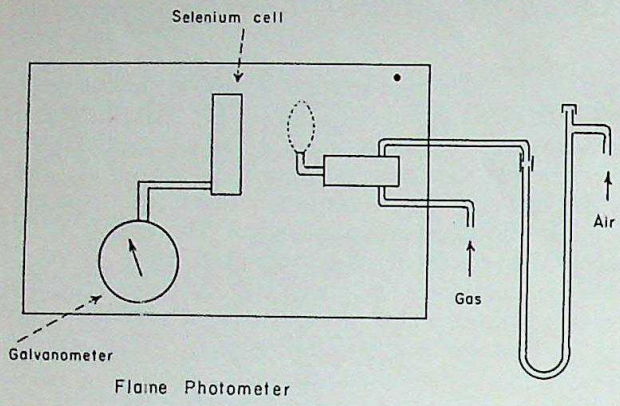

Figure 3. Insertion of Celite column in air stream.

Table 1. Carrier Gas—Compressed Air at 7 lb/sq in.

Mixture	Molar ratio $CHCl_3$: CH_2Cl_2	Area ratio	Chlorine ratio
A	1:1	1.51	1.50
B	1:2	0.81	0.75
C	2:3	1.04	1.00
D	2:1	3.1	3.00

That the areas bore a direct relationship to the total amount of chlorine present in each component was to be expected as the copper wire detector system is in fact trapping chlorine only. In this connection it was observed that for mixture D, which contained the highest proportion of chloroform, it was necessary to replace the single strand of copper wire used as detector by a copper coil in order to obtain area results which showed good agreement with the chlorine ratio.

Subsequent experiments revealed that the combination of the gas chromatographic column with the flame photometer could be used for detecting a wide range of organic compounds embracing hydrocarbons, halogenated hydrocarbons, ethers, aldehydes, ketones, amines, and esters, without the use of a special copper detector for halogenated compounds. Provided the vapor which is being detected causes an alteration in the luminosity of the flame, the photometer will serve as an efficient detector; and the only compounds tested which could not be detected satisfactorily were methanol and ethanol.

Table 2. Time and Duration of Flames for Organic Compounds in Demonstration Apparatus

Compound	Appearance of flame (sec)	Duration of flame (sec)
Acetaldehyde	35	20
Ethyl chloride	40	20
Acetone	76	34
Diethyl ether	80	30
n-Pentane	80	20
Methyl iodide	85	30
Methylene chloride	98	38
Methyl acetate	100	50
Ethyl amine	150	40
Chloroform	190	55
n-Hexane	210	50
Benzene	295	105
Cyclohexane	340	100
Cyclohexene	385	120

Table 2 shows the results obtained with various classes of volatile organic compounds using compressed air at 7 lb/sq in. as carrier gas. The time taken for the vapor to appear is noted and also the time of duration of the flame so that from the data provided in Table 2, one can predict which mixtures of the compounds shown could be separated by the procedure described. For example, there would be no difficulty in separating the components of a mixture containing acetone and chloroform, or *n*-pentane and *n*-hexane, or *n*-hexane and benzene. It was also found, that under a standard set of conditions, viz., constant pressure of carrier gas and constant room temperature, the retention times for various compounds could be reproduced to within a few seconds representing a divergence of less than 5%. For higher boiling compounds, the U-tube may be immersed in a constant temperature oil bath, but this does not add to the teaching value of the apparatus.

U.S. HEW New Publications

The office of Education of the U.S. Department of Health, Education and Welfare has recently issued "Educational Media Research in the Far East" (0E 34025—$0.70). It includes a survey of the overall educational situation in the Far East and a country-by-country report on the progress of projects using new media, e.g., television.

Another recently released pamphlet is "Science Publications, An Annotated Guide to Selected Listings" (0E 29046—$0.40). It is, in effect, a list of published lists of books and reading materials suitable for school students and teachers. All areas of biological, physical, and earth sciences are covered.

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Determining Activity Coefficients by Gas Chromatography

A physical chemistry experiment

Classical methods of determining activity coefficients of non-electrolytes are laborious (*1*) and not as accurate or precise as desirable (*2*). On the other hand, the use of gas-liquid chromatography affords a fast, simple method for making these measurements. A simple, gas-liquid chromatographic experiment which can be performed by students in undergraduate physical chemistry is outlined for the determination of the activity coefficients of benzene, cyclohexane, and cyclohexene in dinonylphthalate.

Since the column of the gas chromatograph can be considered the site of a dilute solution, a correlation exists between gas-liquid chromatographic data and the activity coefficient of a solute in solution. The necessary link is found in the specific retention volume, V_g, which by definition is the volume of carrier gas reduced to zero °C which is necessary to elute a given solute, per gram of liquid phase. This quantity is independent (to a first approximation) of any of the operational variables of the column; it is a function of the temperature alone. It measures the amount of time spent by the solute in the moving gas phase, which in turn is determined by how easily the solute can "escape" from the solvent into the moving phase. The "tendency to escape" is simply vapor pressure. Like other solution properties, it is altered by non-ideal behavior, and therefore activity coefficients are necessary in order to reconcile observed behavior with ideal behavior. Various investigators have successfully demonstrated this relationship between activity coefficients at infinite dilution and the gas chromatographic retention volume (*2–7*).

The simplicity of the gas chromatographic technique makes the measurement of activity coefficients by this method attractive for student instruction. The data which are obtained are accurate and can be used to explain some of the deviations from Raoult's Law; i.e., the nature of intermolecular forces in solution and the resultant deviations from ideality. Overall, this represents an ideal teaching situation.

Two very different instruments were used in this study; an F&M model 720 dual column gas chromatograph, and a home-made one. The latter was built around a Gow-Mac model 9285, 4-filament thermal conductivity cell[2] and used a Sargent Model SR recorder for readout. Using the same home-made column in both instruments, good results were obtained.

Column temperature was maintained between 40 and 60°C and had to be accurately measured. This was accomplished with either an accurate thermometer or a thermistor incorporated into a wheatstone-bridge type circuit. The injection port (and in the case of the F&M instrument, the detector as well) was kept at about 150°C. Helium was used as the carrier gas; flow rate was about 60 ml/min and was measured on the exit side of the carrier-gas line with a soap-bubble flow meter. A student-made manometer, placed in the carrier-gas line on the inlet side served to measure the inlet pressure. Samples were kept as small as practical (about 0.5 μl) and were injected with a 10 μl syringe.

Column. It is necessary that the liquid phase be pure, and that the exact amount of liquid phase in the column be known. Dinonylphthalate (molecular weight = 418.6) was obtained from Analytical Engineering Laboratories, Inc. and was used without further purification. The column packing contained 25.0% dinonylphthalate on 80 to 100 mesh Chromosorb. For the 3 ft of $^1/_4$-in. copper tubing used, this required a mixture of 2.50 g dinonylphthalate and 7.50 g oven-dried Chromosorb.

The efficiency of this column was found to be 525 theoretical plates. Such a column, if used below 125°C should be good for a minimum of 100 hr. A new column should be preconditioned for about 4 hr at 80°C before use.

The Experiment

The instrumental conditions prescribed earlier should be set at least 1 hr before any runs are made, in order to allow the column to come to equilibrium. With the recorder running, a 0.5 μl sample (including some air) is injected. The instrument sensitivity is adjusted so that the peak which is obtained is at least 20% of full scale. Samples of benzene, cyclohexane, and cyclohexene are run.

The following measurements are required:

Flow rate, F; av. of values taken before and after the run: in ml/min.
Adjusted retention time, t_R'; measured from the air peak; in cm.
Column temperature, T_c; in °K.
Room temperature, T_a; in °K.
Atmospheric pressure (outlet pressure), P_0; in cm Hg.
Column pressure (manometer reading), P_x; in cm Hg.

Total inlet pressure, $P_i = P_0 + P_x$.

Calculation.[3] The specific retention volume, V_g (in ml/g), can be calculated from equation (1):

[1] Abstracted in part from an honors thesis submitted by Susan Kenworthy to the faculty of Drew University, 1963.
[2] This cell is part of a kit from which the gas chromatograph was built.
[3] A sample calculation is available to instructors upon request to Dr. Miller.

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$$V_g = \frac{P_0 - P_w}{P_0} \times \frac{273}{T_a} \times F \times \frac{t_R'}{2.54} \times \frac{1}{W_L} \times j \qquad (1)$$

where W_L = 2.50, the weight of the liquid phase in grams, P_w is the vapor pressure of water at room temperature, (T_a); and j is pressure gradient correction factor and equal to

$$\frac{3}{2}\left[\frac{(P_i/P_0)^2 - 1}{(P_i/P_0)^3 - 1}\right]$$

The factor, $t_R'/2.54$, is used because the recorder speed was 1 in./min and t_R' was measured in centimeters. If a different recorder speed is used, a new term will be needed in equation (1). The units on this term (taking into account the recorder speed) should be minutes.

Activity coefficient,[4] γ°, is related to specific retention volume by equation (2) (*8*):

$$\gamma^\circ = \frac{17.05 \times 10^6}{V_g \times f^\circ \times M} \qquad (2)$$

where M = the molecular weight of the liquid phase, and f° = the fugacity of the pure solute vapor in millimeters of mercury. To a first approximation, vapor pressure of the pure solute, p°, at the column temperature, can be substituted for fugacity, and can be calculated from data found in several reference works (*9*). Typical results are shown in the table.

Discussion

Benzene, cyclohexane, and cyclohexene were chosen for this experiment because comparable activity coefficients were already in the literature and showed a wide range of values. The close agreement between literature values and student values is shown in the table and indicates the reliability of this simple method.

A low activity coefficient ($\gamma^\circ < 1$) means that the partial pressure of the solute above solution is less than would be expected if Raoult's law were valid ($p = xp^\circ$). This implies that the solute molecule is being "held" in solution by some intermolecular force, hence reducing its "escaping tendency." We note that the escaping tendency of cyclohexane (γ° = 0.82) is greater than that of cyclohexene (γ° = 0.64) which, in turn, is greater than that of benzene (γ° = 0.52). Such negative deviations from Raoult's law can usually be attributed to one or both of the following causes: inequalities in the volumes of the molecules and disparities in their respective intermolecular forces.

[4] The superscript denotes "at infinite dilution." While this notation is preferable from a theoretical point of view, it must be admitted that this ideal is not attained in a gas chromatographic column, see (*11*).

In gas chromatography, the first cause is often important because the solvent molecule is usually much larger in size than the solute. In this study, however, this effect can be of only minor significance since the three solutes studied are nearly equal in size. Hence, the large differences in activity coefficients must be attributed largely to the second reason.

Dinonylphthalate is a moderately polar substance, and therefore it should be capable of polarizing the delocalized π-electrons of a solute molecule. For the three compounds being studied, the extent of polarizability, and hence the activity coefficient, depends upon the *number* of π-electrons. Since benzene has the largest number of π-electrons, the dispersion and induction forces present in its solution should be the highest, causing its activity coefficient to be the lowest. Cyclohexane, on the other hand, has no π-electrons and can be polarized only slightly. Its interactions with dinonylphthalate will be the smallest and its activity coefficient the largest. Cyclohexene has one double bond (2 π-electrons) and its activity coefficient lies in between benzene and cyclohexane as would be expected.

In addition, the previous considerations enable one to judge the selectivity of dinonylphthalate as a stationary liquid phase and to predict its utility for gas chromatographic separations. The relative volatility of two solutes x and y, (or the "separating power" of a substrate), $\alpha_{x,y}$, is given in equation (3) (*10*):

$$\alpha_{x,y} = \frac{(\gamma^\circ p^\circ)_x}{(\gamma^\circ p^\circ)_y} \qquad (3)$$

If α = 1, the substrate is completely unselective for x and y.

When α is evaluated for benzene and cyclohexane (x and y) in dinonylphthalate, one finds that the ratio of their vapor pressures is almost unity (see the table), so that α can be reduced to:

$$\alpha = \frac{\gamma^\circ \text{ cyclohexane}}{\gamma^\circ \text{ benzene}} = \frac{0.82}{0.52} = 1.6 \qquad (4)$$

Hence, it can be concluded that in this example, the separation was made on the basis of relative activity coefficients.

In gas chromatography, the prediction of activity coefficients and relative volatilities would be helpful in the selection of a liquid phase for a given separation. A theoretical approach to this problem has been taken (*11*), and the results of such studies should eliminate the need for extensive trial-and-error in the selection of a liquid phase for a given separation.

It is hoped that this experiment will stimulate the reader to try some similar experiments of his own: The effect of changing the inlet pressure or the sample

Typical Results.

Compound	F (ml/min)	t_R' (cm)	T_c (°K)	P_0 (cm)	P_i (cm)	p° (mm)	V_g (ml/g)	γ°	Av. γ°	Literature values Ref. (*2*)	Ref. (*7*)
Benzene	52.2	47.4	326	75.8	125.5	303.7	256	0.523	...	...	...
	51.3	50.9	325	75.2	123.3	292.6	270	0.515	...	...	...
	48.0	52.0	326	75.8	122.2	303.7	262	0.511	0.52	0.526	0.524
Cyclohexene	51.7	42.1	326	75.2	123.9	280.2	226	0.644	0.64	...	0.682
Cyclohexane	49.2	31.3	326	75.8	123.7	303.5	160	0.838	...	...	...
	52.6	31.0	326	75.2	124.4	303.5	168	0.796	0.82	0.842	0.849

The experimental data in this table were selected from a larger table of data because they were determined at a T_c of about 326°K. This was done in order to permit a comparison with the literature values which were also determined at this temperature.

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size could be examined; the affinity of other non-polar solutes could be determined; or other solution parameters such as partition coefficient and heat solution could be studied.

Literature Cited

(1) See, for example, Daniels, F., et al., "Experimental Physical Chemistry," 6th ed., McGraw-Hill Book Company, New York, 1962, pp. 54–9.
(2) Adlard, E. R., Khan, M. A., and Whitham, B. T., in "Gas Chromatography 1960," Scott, R. P. W., ed., Butterworths Scientific Publications, London, 1960, p. 252.
(3) Hardy, C. J., *J. Chromatog.*, 2, 490–8 (1959).
(4) Ashworth, A. J., and Everett, D. H., *Trans. Faraday Soc.*, 56, 1609–18 (1960).
(5) Keulemans, A. I. M., "Gas Chromatography," 1st ed., Reinhold Publishing Company, New York, 1957, p. 174.
(6) Pollard, F. H., *J. Chromatog.*, 4, 451 (1961).
(7) Martire, D. E., Unpublished data.
(8) Purnell, H., "Gas Chromatography," J. Wiley and Sons, New York, 1962, p. 206.
(9) See, for example, Jordan, T. E., "Vapor Pressure of Organic Compounds," Interscience Publishers, New York, 1954; three volumes compiled by Dreisbach, R., "Physical Properties of Chemical Compounds," American Chemical Society, Washington, D. C., 1955, 1959, 1961; Timmermans, J., "Physico-chemical Constants of Pure Organic Compounds," Elsevier Publishing Co., New York, 1950; "Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compounds," American Petroleum Institute Research Project 44, Carnegie Press, Pittsburgh, 1953.
(10) Keulemans, A. I. M., *op. cit.*, p. 162.
(11) Martire, D. E., *Anal. Chem.*, 33, 1143–9 (1961).

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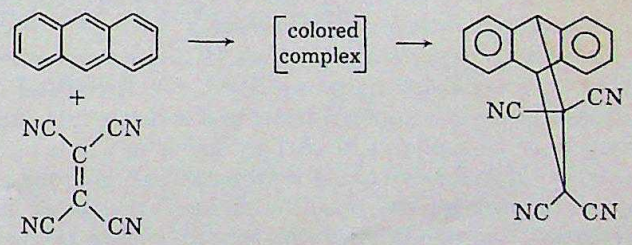
A Diels-Alder Student Preparation

We find that a Diels-Alder reaction between tetracyanoethylene (Columbia Organic Chemicals Co., Inc.) and anthracene (Eastman practical) serves very well for a simple, rapid student preparation for our course in organic chemistry for pharmacy students.

The formation of this adduct was first reported by Middleton, *et al.*,[1] using tetrahydrofuran as a solvent; later, Schimelpfenig[2] employed the reaction in benzene as a lecture demonstration. We use a mixture of these solvents to reduce the volume of the reaction mixture and yet provide a system in which the adduct is insoluble.

We discuss in the prelaboratory session a simple mechanism of the Diels-Alder reaction which includes the formation of a pi-electron complex. It is pointed out that the green color observed in this reaction could be such an intermediate, but that the issue has not been proven. The discussion also covers formation of other pi-electron complexes by tetracyanoethylene with aromatic systems. A variety of these are mentioned (with color photographs) in a *Chemical & Engineering News* special feature article.[3]

Using the parent structure 9,10-ethanoanthracene,[4] we named the product 9,10-dihydro-11,11,12,12-tetracyano-9,10-ethanoanthracene. A name based on bicyclooctane was also devised, and a tinkertoy model prepared to illustrate the unusual structure and to point up the basis for naming.



The Experiment

A solution of 1.3 g anthracene is prepared in 100 ml benzene contained in a 250-ml beaker. A freshly prepared solution of 0.7 g tetracyanoethylene in 5 ml of tetrahydrofuran is then added. Immediately a dark green color forms which soon begins to fade. As the color fades, a flocculent precipitate of adduct forms; in less than 10 min, with only occasional agitation, the green color has disappeared and precipitation is complete. The precipitate is filtered with suction and then recrystallized from a minimum amount of acetone. The yield of once-recrystallized material is about 80%. It melts at 263°(d) (sealed tube); reported 268–270°.[1]

[1] Middleton, W. J., Heckert, R. E., Little, E. L., and Krespan, C. G., *J. Am. Chem. Soc.*, 40, 2783 (1958).
[2] Schimelpfenig, C. W., J. Chem. Educ., 36, A379 (1959).
[3] McKusick, B. C., and Biehn, G. F., *Chem. and Eng. News*, 38, 114 (1960).
[4] Patterson, A. M., Capell, L. T., and Walker, D. F., "The Ring Index," 2nd ed., ACS, Washington, D. C., 1960, p. 720.

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An Improved Synthesis of 2-Bromonaphthalene

An improved synthesis for the large scale preparation of 2-bromonaphthalene has been developed. Of the two usual methods of preparation used in our laboratory to prepare this necessary intermediate (*1*) that of Newman and Wise (*2*) has been discontinued due to the necessity of using the carcinogenic 2-naphthylamine (*3*) and due to the rather vigorous evolution of gas upon addition to a hot flask of the complex salt, $(C_{10}H_7N_2Br)_2 \cdot HgBr_2$. Just recently we had a violent explosion on attempting to vacuum dry a 5-lb quantity of the mercury salt at 30°. The method of Wolfe and Doukas reported in THIS JOURNAL (*4*), which employs 2-naphthylamine-1-sulfonic acid, is adaptable to large scale reactions (2 moles) and affords yields of about 50%.

We found, however, that the 2-bromonaphthalene product resulting from this synthesis would only form a Grignard reagent in about 15% yield as determined by titration (*5*). It is interesting to note that a commercially prepared 2-bromonaphthalene purchased for use in this laboratory also formed the Grignard reagent in fifteen percent yield. An elemental analysis[3] was obtained on this commercial product which indicated a 3:1 ratio of 2-chloro:2-bromonaphthalene.

It was reasoned that upon addition of the diazonium chloride to a solution of CuBr in HBr there would be equilibration of Cl^- with CuBr and both CuBr and CuCl would be present. Hence a mixture of 2-chloro and 2-bromonaphthalene would result.

Fieser and Fieser state (*6*) that HCl is not as satisfactory an acidifying agent as H_2SO_4 for converting a diazonium salt to a phenol because the diazonium salt group may be replaced in part by halogen. It is also stated in this reference that for preparation of a bromide by the Sandmeyer reaction, the amine is diazotized in H_2SO_4 and the resulting aryldiazonium sulfate treated with a solution of CuBr in excess HBr. This suggests that the presence of chloride ion during the preparation of an aryl bromide from an amine might cause some of the intermediate diazonium salt to be converted to aryl chloride.

The proposed mechanism of Cowdry and Davies is as follows (*7*):

$$Ar\overset{+}{N}{\equiv}\ddot{N}\,Cl^- + CuCl \rightarrow Ar\ddot{N}{=}\ddot{N}^+ + Cl{-}\overset{-}{Cu}{-}Cl$$

$$\downarrow \text{slow}$$

$$ArCl + N_2 + CuCl \leftarrow \left[-Ar-\ddot{N}=\ddot{N}-Cu \begin{matrix} Cl \\ Cl \end{matrix} \right]$$

If the CuCl were replaced by CuBr the bracketed intermediate would be

$$\left[-Ar-\ddot{N}=\ddot{N}-Cu \begin{matrix} Cl- \\ Br \end{matrix} \right]$$

and obviously both ArCl and ArBr would result from its decomposition.

Gas chromatographic analysis of the products obtained using methods *A*, *B*, and *C* (see experimental section) were consistent with the above statements.

By altering the method of Wolfe and Doukas to exclude any chloride ion we were able to synthesize 2-bromonaphthalene (in comparable yields) that afforded a Grignard reagent in about 85% yield. This is in agreement with the value given in Kharasch and Reinmuth (*8*).

Preparation of 2-Bromonaphthalene

Method A.[5] The method of Newman and Wise was followed exactly using double quantities. Yield: 76.2 g (52.6%); mp 54–6°. On gas chromatographic analysis[4] a sample showed only one peak at an elution time of 17 min, corresponding to 2-bromonaphthalene.

Method B. The method of Wolfe and Doukas was followed exactly. Yield 197.5 g (47.7%); mp 56.7°; analysis calculated for $C_{10}H_7Br$: C, 58.00; H, 3.41; found: C, 69.27; H, 4.15. This analysis is consistent with 3:1 ratio of 2-chloro:2-bromonaphthalene. On gas chromatographic analysis[4] a sample showed two peaks, one at elution time of 11 min, corresponding to 2-chloronaphthalene, and one at 17 min, corresponding to 2-bromonaphthalene. The areas traced indicated 78% 2-chloronaphthalene and 22% 2-bromonaphthalene.

Method C. A solution of 82 g (2.05 moles) NaOH in a total aqueous volume of 3600 ml was prepared in a two gallon jar. To this was added, with stirring, 446 g (2.00 moles) 2-naphthylamine-1-sulfonic acid. An aqueous solution of 138 g (2.00 moles) $NaNO_2$ was then added and the solution was filtered through a fluted filter paper. The filtrate was then added slowly, with stirring, to 1 l of 37% HBr in a five gallon jar. The temperature was kept below 5°. This was filtered with suction and the precipitate was washed with 2 l of ice water.

[1] Abstracted in part from the PhD theses of T. J. Delia and P. Polss, presented to Virginia Polytechnic Institute in 1961 and 1962 respectively.

[2] Special freshman research participant.

[3] Geller Microanalytical Laboratories, Bardonia, N. Y.

[4] The gas chromatography data were obtained on a Beckman Model 2-A gas chromatography unit. The column was 6 ft. × 1/4 in. od, packed with C-22 Firebrick 42/60 mesh coated with Silicone 550 (30%), and was operated at 220°. The samples were 2 μl of a solution of 0.25 g material in 1.0 ml acetone.

[5] 2-Naphthylamine is available from Pfister Chemical Works, Ridgefield, N. J.

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Grignard Reagent Titration

Sample from method	H_2SO_4 (ml)	N H_2SO_4	NaOH (ml)	N NaOH	Aliquot (ml)	Total vol. Grignard (ml)	2-Bromo-naphthalene (moles)	Grignard reagent formation (%)
A	10.00	0.834	10.10	0.806	1.00	180.0	0.40	90.0
B	10.00	0.454	17.85	0.242	1.00	250.0	0.40	13.8
C	10.00	0.454	12.78	0.242	1.00	300.0	0.50	86.7

During the above slow addition, CuBr in HBr was prepared exactly as in the literature (*9*). The damp diazonium salt precipitate was added portionwise with stirring to the CuBr in HBr in a five gallon jar. After a vigorous evolution of N_2, the solution was heated to 90–5° on a steam bath, and filtered while hot.

To the filtrate in a 4-l beaker was added 450 g KBr with stirring. The resulting paste was allowed to cool to room temperature, filtered, washed with 1 l 20% KBr, and air-dried overnight.

The air-dried solid was added to 800 ml concentrated H_2SO_4 and 800 g crushed ice in a 5-l one-neck round-bottom flask equipped with a water condenser and heated under reflux for 14 hr. After cooling to room temperature the mixture was poured onto 2 kg of crushed ice, and extracted with 3 l of benzene. The benzene layer was washed with water until neutral to litmus paper, concentrated and distilled (4.5 mm): yield 232.3 g (56.2%); bp 122–7°.

The product was dissolved in 1 l of *n*-hexane and allowed to drip through a column packed with 2-in. basic alumina over 2-in. acidic alumina. The column was eluted with a second liter of *n*-hexane. The solvent was removed in a flash evaporator, and the product was dried overnight in a vacuum desiccator. Yield 229.5 g (55.5%); mp 54–6°; analysis calculated for $C_{10}H_7Br$: C, 58.00; H, 3.41; Br, 38.59; found: C, 58.02; H, 3.49; Br, 38.57.[6] On gas chromatographic analysis[4] a sample showed only one peak at an elution time of 17 min, corresponding to 2-bromonaphthalene.

[6] Galbraith Laboratories, Knoxville, Tenn.

Literature Cited

(1) Vingiello, F. A., and Borkovec, A., *J. Am. Chem. Soc.*, **78**, 1240 (1956).
(2) Newman, M. S., and Wise, P. H., *J. Am. Chem. Soc.*, **63**, 2847 (1941).
(3) Hieger, I., "Carcinogenesis," Academic Press, New York, **1961**, p. 60.
(4) Wolfe, W. C., and Doukas, H. M., J. Chem. Educ., **28**, 472 (1951).
(5) Gilman, H., Zoellner, E. A., and Dickey, J. B., *J. Am. Chem. Soc.*, **51**, 1576 (1929).
(6) Fieser, L. F., and Fieser, M., "Organic Chemistry," 3rd ed., D. C. Heath and Co., Boston, Mass., **1956**, p. 613.
(7) Cowdry, W. A., and Davies, D. S., *J. Chem. Soc.*, **1949**, 548.
(8) Kharasch, M. S., and Reinmuth, O., "Grignard Reactions of Nonmetallic Substances," Prentice-Hall, Inc., New York, **1954**, p. 19.
(9) Hartwell, J. L., in "Organic Synthesis," Vol. 24, Drake, Nathan L., ed., John Wiley and Sons, New York, **1944**, p. 23.

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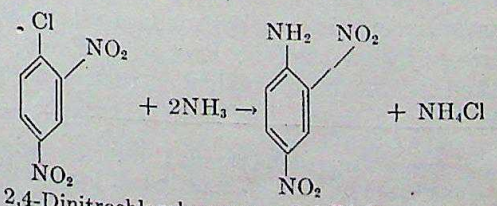
Simple Method for the Preparation of 2,4-Dinitroaniline

The standard practical organic textbooks either do not give a procedure for the preparation of 2,4-dinitroaniline from 2,4-dinitrochlorobenzene or state a method which involves gaseous ammonia.[1] The use of ammonia gas is inconvenient for the preparation by a large class of students because of the limited number of fume hoods and ammonia sources. The author found that 2,4-dinitroaniline could be conveniently prepared by refluxing 2,4-dinitrochlorobenzene in an alcoholic solution with the readily available concentrated ammonia solution.



2,4-Dinitrochlorobenzene 2,4-Dinitroaniline

Procedure. Dissolve 2 g of 2,4-dinitrochlorobenzene in 25 ml of alcohol denatured with methanol[2] in a 250 ml conical flask and then add 10 ml of ammonia solution (sp gr, 0.880). Connect the flask to a water condenser, the top of which is covered by an inverted 50-ml beaker, and reflux the mixture on a water bath at 80° for two hours. Then add an additional 10 ml of the ammonia solution and continue to reflux for another hour. After removing the flask and cooling the contents, collect the bright yellow crystals with suction and wash them with 5 ml of the cold denatured alcohol. Recrystallize the 2,4-dinitroaniline from a mixture of the denatured alcohol and water. Filter the crystals with suction and dry them below 90°. In this way 1.5 g of product melting at 178–180° are obtained.

[1] Vogel, A. I., "A Textbook of Practical Organic Chemistry," 3rd ed., Longmans, Green and Co., London, **1956**, pp. 638–9.
[2] If readily available, ethanol will do.

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Laboratory Cylinder-Mill for Small Samples

Most laboratory workers have been confronted at one time or another with the problem of preparing a small quantity of powdered solid. In the smallest ball mill jars, a gram or two of material is just about enough to coat the balls and wall, and little size reduction occurs after extended periods of rotation; also, recovery of the charge is difficult. This problem has been solved in our laboratory by the design of a small mill that can grind as little as a half gram of coal or other solids; and when opened, the entire volume is easily cleaned.

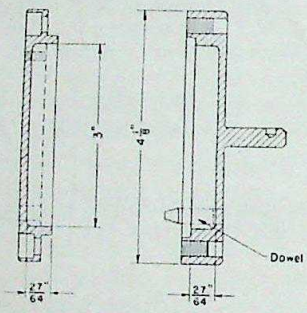

Figure 1. Cylinder mill.

In principle, the mill is a rotating thin cylinder in which smaller cyclinders roll. The rolling cylinders are in contact, and a differential grinding action takes place between them as well as crushing between them and the periphery of the mill. Figure 1 shows the tempered Nitralloy cylinder halves. When they are bolted together, a 3-in. by $^{27}/_{32}$-in. cavity, having a volume of less than 100 ml, is formed. The mill is rotated by the assembly shown in Figure 2. A small gear reduction motor[1] drives a pulley set which rotates the mill arbor. Speed control between 0 and 120 rpm is provided by a 500 W bench type variable voltage transformer in the power line to the motor.

For convenience of assembling and removal of the mill from the drive system, a handle is bolted to the cover plate. The extension on the other half of the mill fits into a hole in the base plate. The motor and arbor support block are mounted on a steel base plate. The entire unit can be placed inside a dry box.

The sample (for example 0.5–10 g of 60-mesh coal) is placed in the right half of the mill; one to four Burundum®[2] grinding cylinders are placed upright; and the halves are bolted together. The halves are always oriented toward each other in the same manner by alignment of the dowel index and hole. The assembled mill is snapped into the drive shaft, and rotation is started. The speed is slowly increased to a point where the cylinders roll smoothly without lifting and dropping. After grinding, the mill is removed from the drive shaft, placed in a horizontal position, and opened. The sample is removed easily; the interior can be cleaned with a camel's hair brush. At the end of a 4 hr grinding, all of a coal sample is usually finer than 325-mesh.

Commercial Burundum cylinders are approximately $^{13}/_{16}$ in. × $^{13}/_{16}$ in. There is some small size variation in a particular lot, so some care should be taken in selecting the cylinders used. If too long, they will bind against the end plates and not roll freely. The undersize length is not critical, but should be a reasonably good fit so that the cylinders will not tilt and bind. In the design presented here, a clearance of $^{1}/_{32}$ in. is provided. Care should be taken in the machining to provide the $^{3}/_{32}$-in. radius corner on the internal circumference of the mill. This conforms approximately

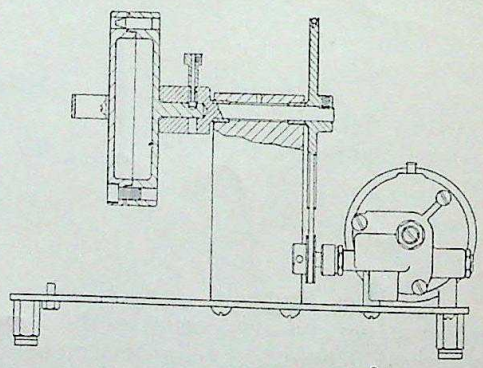

Figure 2. Mill assembly.

to the curvature of the cylinder and eliminates a potential dead volume. Cylinders made of steel, brass, or other materials can be used.

The unit described has been in continuous use for about 5 years and its popularity has prompted the construction of additional units. Engineering drawings are available from the authors.

Acknowledgment is hereby made to the Bureau's Engineering Design staff at Bruceton, Pennsylvania, who worked out the many small construction details.

[1] *Bodine Company, Type V-10R. Reference to specific brands or makers of equipment is made to facilitate understanding and does not imply endorsement by the Bureau of Mines.*

[2] U.S. Stoneware Company, Akron, Ohio. The selection of Borundum was based on its high density and hard ceramic surface (9+ on the Mohs scale).

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Proceedings of the

California Association of Chemistry Teachers

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Organic Semiconductors

An organic semiconductor may be defined as a structure containing an appreciable number of carbon-carbon bonds and which is capable of supporting electronic conduction in the manner of inorganic semiconductors (*14*). The history of the study of photoconduction in poorly-conductive organic compounds goes back to the turn of the century. Photoconductivity in solid anthracene was discovered by Pocchettino (*32*) in 1906. At this time attempts were made to relate the phenomenon to the external photoelectric effect, but Volmer (*39*) showed that photoconduction in anthracene sets in at 4000 Å (*ca.* 3 ev), whereas actual ejection of electrons is only observed below 2250 Å (5.5 ev). The existence of a small but measurable dark conduction in anthracene was reported, and it was noted that the conductivity in the molten state was greater than that in the solid state. After the appearance of a spate of papers on the subject in the years just before 1914 (*15*), interest in organic semiconductors seems temporarily to have lapsed. In the years between the wars, a certain amount of work was done on photoconduction in organic dyestuffs, with particular reference to the part played by these in the "sensitization" of photographic emulsions (*37*). In 1941 Szent-Gyorgi suggested that the transfer of pi-electrons from molecule to molecule might play an important role in the fundamental physical processes of living organisms and this provided considerable stimulus in the study of organic semiconductors (*36*). Szent-Gyorgi later reported the existence of photoconduction in certain dyed proteins as evidence supporting his suggestion (*44*). In succeeding years there has appeared a considerable number of papers on the subjects of conduction and photoconduction in organic materials. In 1948 it was reported (*15*) that the conductivity of the phthalocyanines is an exponential function of the temperature, as is the case for many inorganic semiconductors. More recently the use of anthracene for crystal counters in nuclear physics has promoted the study, first, of photoconduction and then of dark conduction in this material. During this time, the possible biophysical implications of organic semiconduction seem constantly to have been in men's minds (*48*). The theories of photosynthesis proposed by Calvin and his co-workers appeal to "photoconduction" in the sense that light has to be absorbed at one point, at which it is used to promote some oxidation-reduction reaction. Indeed, photoconduction has been detected in chlorophyll *in vitro*. At any rate, as a result of an extensive series of investigations of a large number of materials, it is now clear that semiconduction (in the sense of a low conductivity which increases with increasing temperature) and photoconduction are common, if not perhaps universal, attributes of organic materials containing closed rings of alternating double and single bonds (delocalized electrons, conjugation), and of some other materials of less specific structure (such as proteins and technical polymers) as well.

Nature of Organic Semiconduction

Let us state exactly what phenomena are in question. We are concerned with charge transfer in a bulk sample—preferably a single crystal—whether stimulated thermally or optically. For such transfer to occur, electrons (or possibly protons) must actually move from molecule to molecule—not just around a closed ring or down a long molecular chain. Unfortunately this distinction is seldom made clearly in the literature (*18*), and so a few comments may be in order. The pi-electrons in benzene may be considered, in the zeroth approximation that ignores exchange effects, to form a half-filled zone. If a steady magnetic field is applied in a direction perpendicular to the ring, the electronic states will shift in such a way as to give rise to a net diamagnetic moment associated with the ring. We may, however, look at this in another way, which is more revealing for our present purposes. During the

Presented in part at the Fourth Summer CACT Conference, Asilomar, California, August, 1962. The previous two papers on this topic (Electronic Interpretations of Physical Properties) appeared in THIS JOURNAL, **39**, 596 (1962) and **40**, 489 (1963).

[1] Visiting Professor, 1963, on leave from Pasadena City College.

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process of application of the magnetic field, an emf is induced in the ring. In the presence of the field there is a net component of "crystal momentum," ρ, clockwise or counterclockwise as the case may be—that is to say a net current flowing around the ring. The electrons of positive ρ have slightly higher energy than those of negative ρ, but, since the separations between the individual electronic levels are quite large (several ev), there are no immediately accessible states into which the electrons of positive ρ may go. In other words, there is no dissipative mechanism; and, from the point of view of electron flow around the ring, benzene is not a semiconductor, but a *superconductor*. On this basis it is possible quantitatively to account for the observed diamagnetic anisotropy in benzene, and this has been extended to the higher conjugated aromatic hydrocarbons. The reason why many of these materials in fact show *semiconducting* properties in the crystalline state cannot, therefore, be sought within the molecule itself. The "slow step" in the conduction process has to be the actual transfer of electrons from molecule to molecule; and this is a problem for which as yet no adequate theoretical treatment exists, although a modified electronic-band model has been successful in explaining some experimental transport properties, as will be shown below. A macromolecular material for which a single molecular orbital wave-function may be written for an entire crystal or crystal domain has seemed a promising approach to bulk charge transfer, therefore, in organic compounds (*45*).

The major goal of present research programs is to understand the mechanisms of electronic conductivity in such materials and to relate these mechanisms to the physical-chemical structure of the solid. While the present state of this understanding may be compared to that of inorganic semiconductors of about 35 years ago (*40*), the intriguing possibility of "tailoring" the electrical properties through organic chemistry is reason enough for substantial research activity. It is possible, currently, to develop a wide range of mechanical properties in organic solids through preparation of specific molecular structures. If this same variety can be extended to electrical parameters, the scope of semiconductor applications is likely to be expanded far beyond that made available by use of the two commercially important inorganic semiconductors, silicon and germanium, and of the inorganic semiconducting compounds like gallium arsenide.

Various organic materials display feeble electrical conductivity that increases with increasing temperature, and may also demonstrate photoconductivity. Semiconducting organic solids fall into two major categories: well-defined substances (molecular crystals and crystalline complexes, isotactic and syndiotactic polymers, etc.) and disordered materials (atactic polymers and pyrolytic materials).

Molecular Crystals

The classical example of a molecular crystal is anthracene, which is probably the most extensively studied organic semiconductor. There is now experimental evidence that some of the transport properties of anthracene are not unlike those familiar from studies on silicon and germanium. Hole and electron mobilities of the order of 1 cm^2/v-sec can be measured in zone-refined crystals. These drift-mobility experiments employ photoconductivity, since the crystal is a poor conductor in the dark. There is also experimental evidence that carriers are produced only on the surfaces or at electrodes by excitation waves (or "excitons") generated at the point of photon absorption. These experimental transport properties can be explained on the basis of a *modified* electronic-band model of solids. Calculation of the width of the energy bands proceeds by computing overlap integrals between pi-electron molecular wave functions on adjacent molecules. Because the intermolecular binding is weak in molecular crystals, the overlap is small and leads to narrow energy bands, which implies small carrier mobilities. The calculation is also successful in accounting for observed mobility-anisotropies. This demonstration of the success of a band model in explaining transport properties in organic semiconductors is comforting in that many of the concepts developed for inorganic materials are immediately applicable. Less comforting is the equally important conclusion that in order to observe the basic properties of the customary "small-domain" organic crystals, purification techniques as extensive as those applied to inorganic materials must be applied. Nevertheless one may still hope that useful semiconducting properties might be discovered among "large-domain" organic semiconductors without such careful processing. Zone-refined anthracene single crystals are nearly free from space charge effects due to carrier trapping and furthermore can show *electronic* (n-type) conductivity. Only hole-conduction and many trapping effects were always observed in less pure crystals and have contributed to confusion in experimental results in the past.

Mechanisms for Semiconduction

The exciton states of the simpler aromatic solids have been examined (*8*, *9*, *11*, *12*, *15*, *28*) in the quest to understand organic semiconduction. In these compounds the absorption spectra of the crystals and of the corresponding free molecules are very similar. This suggests that the final state of an optical transition in the solid is essentially a molecular excited state. However, there are features of the crystal spectra which can be explained qualitatively and quantitatively if one assumes that the molecular excitation is not confined to one molecule but is coherently shared by all molecules of a perfect crystal. In such a state—an exciton—the excitation energy and crystal momentum is definite but the position of the exciton is completely uncertain; i.e., it may be considered delocalized. In a classical description of an exciton in a molecular crystal, one may consider the excitation to be mobile, with the electrons involved in the excited state of a particular molecule remaining behind as the excitation passes. In contrast, the classical picture of the exciton in a conventional semiconductor (germanium, silicon, etc.) is that of an electron and hole bound together to form a hydrogen-like atom which moves freely through the crystal carrying along the excitation energy (*41*). In a more general formulation (*13*) of the exciton problem, some of the kinetic energy terms are matrix elements in which there is a transfer between the initial and the final state, of both the excitation and the charges involved in this excitation from one molecule to the next.

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Such charge exchange cannot be in the electronic wave functions of neighboring atoms or molecules are isolated from one another, as is the case in crystals like anthracene. On the other hand, where the overlap is large, the charge exchange is very important, but then the use of atomic or molecular orbitals in building crystal wave functions becomes inaccurate. In such cases one may reformulate the problem, obtaining the well-known model of a bound electron-hole pair moving through the conventional semiconductor (*41*).

One may also transfer excitation primarily through an electric interaction between the transition dipole moments of the molecules. These transition moments are the same as the matrix elements involved in optical absorption, so the interaction is large and the effective mass of the exciton is thereby small if the absorption is strong. The classical model (*41*) is most accurate where the binding between the electron and hole is weak, so that the exciton radius is large. With the electron far from the hole, the optical transition dipole moment will be small so that in crystals like germanium this second mechanism for motion of the excitation may be neglected. On the other hand, aromatic molecules generally have fairly strong optical absorptions, so the second mechanism is important; excitons corresponding to the second anthracene transition have a range of kinetic energies of the order of 1 ev, as have been found experimentally (see above).

A model, similar to the one-electron band model classic to inorganic semiconductors (*19*), may be applied to the *perfect* aromatic molecular crystal (*35*). The free electron will spend most of its time in the neighborhood of one molecule or another, and very little time in the interstitial regions; its wave function will be a linear combination of excited molecular orbitals. Because these orbitals are almost completely isolated from one another, the effective mass of the charge carrier will be large. Free hole states can be treated in a similar fashion. In the case of the excitons, the strong excitation transfer mechanism in aromatic crystals makes up for the weak pair transfer, so that the exciton effective mass may still be small. No such alternative mechanism is known for the conducting states. With a large effective carrier mass, the range of kinetic energies will be of the order of, or much smaller than, kT at room temperature. These kinetic energies may then be smaller than the perturbation energies, so that the model of a free carrier occasionally scattered by imperfections is not valid. With a sufficiently large effective mass in the perfect crystal, a better picture is provided by the "hopping model," in which one assumes that the carrier spends a long time on some molecule; the perturbations arising from the presence of other molecules cause an occasional jump to a neighbor. For intermediate values of the effective mass, it is possible that neither the hopping nor the conventional band picture is valid. To find the excitation energy for the lowest conducting state in the hopping model, one may start with a neutral crystal, remove an electron from one molecule, and place it on another a great distance away (*11*, *28*). Considering this charge transfer to take place in several steps, we first remove the electron from its original molecule to a point far from the crystal; this requires the addition of energy I, the molecular ionization potential. Bringing the electron back to the crystal and placing it on the second molecule regains the energy A, the molecular electron affinity. We now have a widely separated ion pair, and each ion polarizes the surrounding molecules. The energy, W, of interaction of each ion with the polarization is the same for the two ions, approximately. The excitation energy is then $I - A - 2W$. There are other minor terms, of course. Either the electron on the negative ion or the hole left behind on the positive ion may now carry current, by hopping to adjacent molecules. The two charges are sufficiently far apart that they act independently of one another.

Where the optical transition moments for molecular crystals are very small, therefore, one should use a hopping model for the excitation, especially for excitations to the molecular triplet state where the optical transition is highly forbidden. The hopping model is also applicable to such excitations as the O-O component of the first benzene transition, except possibly in a good crystal at very low temperatures (a forbidden transition in the free molecule, but weakly allowed in the crystal). Another excitation in which the hopping model is useful is one in which an electron is transferred to an *adjacent* molecule, leaving a hole behind (*28*). The attraction between the two charges prevents further separation, if no additional energy is supplied. To move this excitation through the crystal, one must also transfer the charge pair. The matrix element for this process is extremely small, and the hopping model should be used, probably even at low temperatures (*29*).

In each of several aromatic crystals, the observed value of the activation energy for dark conductivity, E, turned out to be $^1/_2E_t$, where E_t is the energy of the triplet state of the isolated molecule, measured from the ground state, and E is defined by the first of the following relations:

$$\sigma = \sigma_0 e^{-E/kT} = \sigma_t e^{-E'/2kT}$$

with T the absolute temperature, k the Boltzmann constant, σ the dark conductivity, and σ_0 a constant. The quantity E', introduced to simplify later discussion, is defined as $2E$. The similarity between the last member of the above relations and the expression for the dark conductivity of a conventional intrinsic semiconductor (*19*) led some investigators to assume that E' was the band gap in aromatic crystals. The observed equality between E' and E_t led to the further assumption that the molecular triplet state was involved in the conduction. Since this state is nonconducting, the involvement must be indirect. The validity of the first assumption depends on whether the conductivity is intrinsic; this point has been dealt with by Garrett (*15*); others have shown that the triplet state actually can play no role in organic semiconduction (*11*, *12*). In thermal equilibrium, the population of each conducting state depends on the energy of that level, but not on the mechanisms of transitions between states. The observed value of E' therefore cannot be explained in terms of the excitation of one of the nonconducting states (in particular, the triplet state of a molecule), followed by a transition to the conducting state. If the equality of E' and E_t is not a coincidence, it must arise from a relationship between the structures of the triplet and conducting states. It has been suggested

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that it takes the same energy to raise an electron from the highest filled to the lowest unfilled molecular orbital (with the final spin state a triplet) as it does to place that electron in the same unoccupied state of a distant molecule. When the latter transfer is effected, either the electron or the hole left behind on the first molecule is free to move from one neighbor to another. The population of charge carriers would then have the temperature dependence indicated in the relation above, with the "band gap" E' numerically equal to E_t. One might, as an approximation, use the same molecular wave functions, in the two cases, for the state which the electron enters. But even if the wave functions were identical, the two excitation energies would not be the same. For spinless electrons, the transfer of an electron to a distant molecule involves, among other energy terms, the Coulomb energy of separation of the electron from the positive charge left behind. This contribution, which is not negligible, does not appear in the energy of the triplet state. Second, when the spin is taken into account, we note that each of the two ions produced by the charge transfer is in a *doublet* state; the wide separation of the ions prevents these states from interacting to form a singlet and a triplet. Since the singlet and triplet molecular states differ greatly in energy, there is no reason to expect equality between the energy of the molecular triplet and that of the two ionic doublets. Next, let us assume that for some unknown reason, each set of measurements was carried out on a sample in which there was an equilibrium number of triplet excitations but an abnormally low number of charge carriers. For such a nonequilibrium case, one can set up a rather artificial model in which the current is indirectly determined by the population of the triplet states. This number, however, varies with temperature as $e^{-E_t/kT}$, *not* as $e^{-E_t/2kT}$. If, for this or any other reason, the current were proportional to the triplet population, one should find E, and not E', equal to E_t (in anthracene at room temperature the factor $e^{-E_t/kT}$ is so small that there is a negligible probability of finding even a single molecule in the triplet state); if even the triplet states are not in equilibrium, there should be *no* relationship between E' and E_t. It should also be noted that the factor of $^1/_2$ in the exponent in the case of an intrinsic semiconductor appears because the possible distributions of electrons in the conduction band are independent of the distributions of holes in the valence band. This factor appears also in the case of an equilibrium distribution of ion pairs. However, in molecular excitations, once one determines a distribution of electrons among the excited states of the various molecules, the distribution of "holes" in the ground states is completely determined. In such a case, the factor of $^1/_2$ does not appear. These conclusions are based on some rather general statistical arguments, not restricted to solids. It is required only that the Fermi level (*46*) be far, compared to kT, from any of the one-electron states.

The spacial distribution of trapped charge in anthracene has been subjected to analysis (*21, 33*), and evidence has been presented that indicates that most of the free electrons are injected into the anthracene at the negative electrode and that anthracene is an extrinsic rather than intrinsic photoconductor. If correct, electron-injection is an exponential function of which indicates that the anthracene-metal contact may form a *p-n* junction (*19*).

Charge-Transfer Complexes

A charge-transfer complex is an intermolecular addition compound, composed of an electron-donor (e.g., an aromatic hydrocarbon) and an electron-acceptor (e.g., a halogen). In passing from anthracene to the charge-transfer complexes, we go from one extreme in which the optical evidence for delocalized charge is limited or absent to the other in which electronic delocalization effects are so strong as to overwhelm the optical properties associated with the private molecular energy levels. The metastable $(Perylene)_2(I_2)_3$ and $(Pyrene)(I_2)_3$ complexes (*24*) and the unstable bromine-perylene complex (*3*) show relatively high conductivities (0.01 to 1 mho/cm at room temperature); and they are optically opaque in thicknesses (down) to 1000 Å in the near-infrared, visible, and near-ultraviolet. The activation energy for conduction of these complexes is fairly low (0.14 to 0.01 ev). Labes (*26, 27*) showed that the unpaired-spin concentration in these complexes varied from 10^{18} to 10^{19} cm^{-3} and that, on changing the temperature, the density of unpaired spins changed in the same way as did the conductivity (below 200°K, where the activation energy for conduction in pyrene became altered, the unpaired-spin concentration became temperature-independent). This suggests, as with anthracene, that the major part of the temperature-dependence of the conductivity comes from a change in the carrier *concentration* rather than from any change in mobility. The absolute values for mobility demanded by a comparison of conductivity and spin-resonance data are in the vicinity of 10^{-2} cm^2 $volt^{-1}$ sec^{-1}. Therefore, in these materials, the carrier density at room temperature must be of the order of 10^{14} to 10^{15} times that prevailing in anthracene, each carrier having, however, a mobility of the order of 100 times less.

Quite large conductivities, as high as 100 mho/cm, can be developed in other molecular crystals in which molecular complexes consisting of chemical groups which are electron donors are combined with groups which act as electron acceptors. The electron exchange between such groups has the effect of producing many nearly free carriers and yielding high conductivity even with very small carrier mobilities (usually less than 10^{-2} cm^2 v-sec). The electrical properties of some molecular complexes are nearly metallic-like in many respects, showing degeneracy effects and small or negligible activation energies for conductivity. There is some preliminary evidence that the band model is applicable here also and that again the crucial point is the overlap of electronic wave functions between molecules. The other features of the band structure—e.g., the width of the forbidden gap—are related to the energy levels of the isolated molecule, although intermolecular interactions may not be neglected. It is interesting to note the analogy between the donor-acceptor action of chemical groups in the molecular complexes and the behavior of impurity atoms in germanium and silicon. Recently an interesting new set of compounds having higher electronic conductivity than any others reported has been announced (*1, 2, 4, 6, 7, 16, 17, 23, 30, 43*) by workers at

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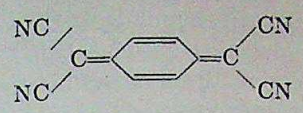
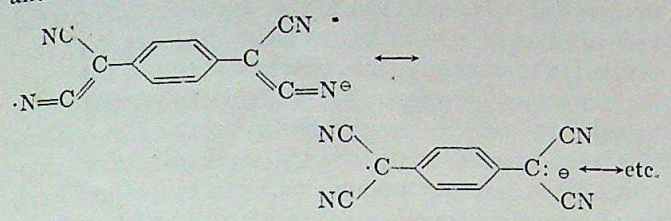
DuPont. These are charge-transfer complex salts of the radical anion of tetracyanoquinodimethane,



and have the generalized structure $M^+(TCNQ^-)$ (TCNQ), where TCNQ is tetracyanoquinodimethane and $TCNQ^-$ is the radical anion



while M^+ is a cation, usually organic, such as the triethylammonium ion. In a few cases, compounds lacking neutral TCNQ have been formed; for example, 5,8-dihydroxyquinoline with TCNQ gave the anion-radical salt, $C_9H_7NO_2H^+TCNQ^-$, resistivity (powder) = 14 ohm-cm. However, quinoline with TCNQ gave $C_9H_7NH^+(TCNQ^-)(TCNQ)$, resistivity (single crystal) equals 0.01 ohm-cm. These complexes have an electron density of one free electron per molecule, and a resistivity of the order 0.01–100 ohm-cm, depending on direction (the electrical resistivity is highly anisotropic along the three principal crystal axes). For comparison, the resistivity of hyperpure silicon is about 1000 ohm-cm, graphite about 10^{-3} ohm-cm and most organic compounds 10^{10}-10^{14} ohm-cm. (The lowest resistivities *previously* reported for organic compounds were those for the metastable halogen-perylene complexes (*3*, *24*).) The electron mobility seems to be very low, although so far only incomplete data (*5*) have been published. The thermoelectric power of about -100μV/°C is characteristic of a good metallic conductor.

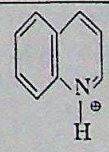
A preliminary theoretical interpretation of these phenomena has been developed (*5–7*). In both types of TCNQ salts the band formed from the lowest normally unfilled MO of TCNQ is partially filled, being half filled for the first series of salts (M^+TCNQ^-) and 1/4 filled for the second. As a result of the relatively weak intermolecular interactions characteristic of molecular crystals, this band will be quite narrow. In addition, both the bandwidth and the exchange coupling of the odd electrons (*6*, *7*) appear to be strongly influenced by the nature of the cation, M^+, and by whether or not TCNQ° is present in the crystal. In the quinolinium salt (see Table 1), the electrons of the ($TCNQ^-$) radicals appear to form a conventional degenerate system similar to a metal. This is evidenced by the very large electrical conductivity, the virtual absence of activation energy for conductivity, and a temperature-independent paramagnetism. The activation energies of the other salts are also low and are isotropic within experimental error although the electrical conductivities are highly anisotropic (the triethylammonium salt has room-temperature values of 4.0, 0.05, and 0.001 mho/cm in the three principal crystal directions, and these vary exponentially with temperature with an activation energy of 0.14 ev). Preliminary crystallographic data show that this salt belongs to the monoclinic C2 space group with four TCNQ formula units per unit cell. The TCNQ units appear to be arranged in infinite face-to-face stacks with the direction of highest conductivity lying along these stacks and approximately normal to the planes of the TCNQ molecules. The thermoelectric power (see above) is in the direction of highest conductivity and this indicates that electrons are the majority carriers in this materials. No Hall voltage has been detected in this salt and this, together with the observed conductivity and the assumption that all of the electrons in the radical-anions participate in carrying the current, leads to the conclusion that the electron mobility in it lies between 0.02 and 0.04 cm²/v-sec. It is possible that charge carrier motion in these materials takes place by an activated hopping process, in which case it is questionable whether a Hall effect should be observed at all, but I feel this interpretation is not as likely.

TCNQ is a strong pi-acceptor. ESR studies (*6*, *7*) show a spin correlation between magnetic electrons in these salts, giving rise to a ground singlet state and a *thermally accessible* triplet state. Typical *S-T* separations (*J*) found are: 0.034 ev for the triethylammonium salt, 0.062 ev for the triphenyl phosphonium and the triphenylarsenium salts, and 0.41 ev for the morpholinium salt. The importance of paramagnetic impurities in studies of the magnetic properties of organic solids must be emphasized. A per cent or so of doublet-state impurity species can dominate resonances near g = 2.002 in molecular solids obeying *S-T* ($S_1 - S_3$) statistics.

(For a strong donor and strong acceptor, as here, complete electron transfer could occur and the system could be expected to exhibit paramagnetic characteristics in the ground electronic state. In the solid, interactions are more extensive than in solution (single molecules in solution) and than pairwise and could provide an electron-conduction mechanism.)

In these salts, M^+ is diamagnetic and $TCNQ^-$ or $(TCNQ)_2^-$ are paramagnetic, and EPR characteristics are attributable to the presence of entities residing in the triplet rather than doublet electronic states. The best model to date (*6*, *7*) shows M^+ forming insulating layers separating adjacent two-dimensional layers of the stacked TCNQ's (face-to-face stack). Formally there are 2 "molecules" per unit cell, i.e., 2 M^+, 2 $TCNQ^-$ and 2 TCNQ°. Evidence has been presented for a model in which triplet electrons exist in an extended pi-system which allows effective distance of separation of electrons larger than for naphthalene and indicates

Table 1. Electronic Properties of Some Radical Anion Salts

Material	Electrical conductivity, mho/cm at 300° K	Activation energy, E_A, in ev
 $[TCNQ\cdot]^{\ominus}$ (TCNQ)	100[a]	<0.01
$(C_2H_5)_3\overset{\oplus}{N}H(TCNQ\cdot]^{\ominus}$ (TCNQ)	4.0[a]	0.14
$K^{\oplus}[TCNQ\cdot]^{\ominus}$	1.9×10^{-4} [b]	0.36

[a] Measured in the direction of highest conductivity.
[b] Compressed-powder sample.

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that the triplet state entity is confined to the vicinity of the TCNQ molecules, *with M^+ functioning mainly as a crystal-field source;* the triplet electrons are not considered as residing on a single TCNQ molecule. Thus the triplet entity is probably at least two TCNQ units, and the electron-pair giving rise to the triplet state may be distributed over all four TCNQ units in the unit cell.

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Polymers

The semiconducting properties of the polymers and similar organic compounds are not nearly so well established as those of the molecular crystals, partly because their physical-chemical structures are not so well characterized. Such materials are usually insulating, but appreciable conductivities can be developed by modification through chemical synthesis or pyrolysis and some 100 different types have been studied. Conductivity activation energies ranging from essentially zero to several electron volts and conductivities from insulators down to within an order of magnitude of 10^2 mho/cm are reported (*47*). Carrier mobilities are very low and these solids are almost always *p*-type. Some evidence exists for chemical impurity effects and zone-refining techniques have been applied to a few compounds. A correlation of experimental measurements of conductivity and thermoelectric power as a function of temperature can be made on the assumption there is possible intrinsic semiconductivity. However, there is no evidence that a band model is applicable to the polymers and the intrinsic picture results in some inconsistencies. Also, interpretations of experimental conductivity activation energies in terms of band-model energy gaps, while quite common, are, as shown above, largely unjustifiable. The lack of an observable Hall effect in nearly all specimens greatly hampers interpretations. There is as yet no clear understanding of structural effects such as the influence of chain length or the number of conjugated carbon atoms per molecule. Indeed, the actual chemical structures of the pyrolyzed polymers, in particular, are often not known (*38*).

Experimental measurements on organic semiconductors are hampered by the fact that many compounds are available only in powder-like form. It is common to study compressed pellets of these materials, which practice introduces serious intergranular effects. Also, unless these are carried out in O_2-free conditions, free radicals form. And there is some evidence for a biradical triplet-state overlap of molecular orbitals. Similarly, electrode influences perturb the experimental results in unknown ways, particularly on high resistivity specimens. In a few specific cases it has been shown that good agreement between single crystals and compressed pellets can be realized, but in other cases there are violent discrepancies between the two. Loss tangent measurements or other ac resistance techniques oftentimes applied in such situations must be approached with extreme caution, as there is no a priori guarantee that the ac losses are related to the dc conductivity.

Solid Free Radicals

The potential box model used to describe the semiconducting properties of organic substances indicates that under favorable circumstances a solid free radical would behave as a semiconductor with very small or zero energy gap and this has proved to be the case in measurements by both ac and dc methods on samples of α,α'-diphenyl-β-picryl hydrazyl (DPPH), on Coppinger's Radical and on Banfield and Kenyon's Radical (*22*). The samples included polycrystalline materials, evaporated films and single crystals. The role of odd electrons in the conduction process in crystals of substances having only partial radical character is less well understood. Indeed, since the existence of partial radical character is in many cases still not fully explained in quantitative and theoretical terms, the problem remains a complex one. Free electrons are known to exist in some polycyclic hydrocarbons like violanthrone and violanthrene, but the semiconducting properties are in no way anomalous. On the other hand, those molecular complexes that are so highly conducting (*1, 2, 6, 7, 16, 17, 23, 24, 30, 43*) are in most cases paramagnetic. Similarly there appears to be some correlation between the semiconductivity and the concentration of free electrons in pyrolized polymers. Thus, further information is required on the properties of unpaired electrons as conducting species.

The idea of conduction by electrons without activation has implications in biophysics. The conductivity of dry proteins is rather low to explain the rates of many metabolic processes in terms of electron transfer. The suggestion has been made that a protein in a suitable environment may lose a hydrogen atom during the course of a reaction, creating a free radical. This is equivalent to creating a positive hole in the conduction band and would result in a lowering of resistance. Unfortunately, the initial activation energy requirements for the creation of the free radical that is not resonance-stabilized is so high as to make this mechanism rather unlikely; the ESR signals observed in biological systems no doubt relate to the less active resonance-stabilized radicals (if we rule out photochemical systems). However, in the case of DPPH, evidence is available to show that the pi-electron, after having been excited to the lowest empty orbital, may then tunnel to the *equivalent* empty level in a neighboring molecule (the levels of the latter, as a whole being lower) closer to the positive electrode. An electron may similarly enter the resultant highest unfilled level from an *equivalent* filled level in a neighboring molecule closer to the negative electrode (and hence of higher potential), which is the same as a positive hole moving in the opposite direction. The permeability factor for the barrier to tunneling determines the mobility of the electron; the usual effects of charge separation are minimized because of the very high polarizability of the surrounding pi-electrons. Compared to charge-transfer complexes, however, the conductivity of such molecules is relatively low. Nevertheless, the existence of unpaired electrons in complexes is indicative of ground-state bonding with a large ionic component. Narrow line widths are also indicative of this strong exchange interaction. Such molecular complexes thus represent semiconductors (by virtue of their *activated* charge transport) with the following peculiarities: (1) they are very insensitive to impurities; (2) they have extremely low mobilities; and (3) they exhibit a proportional increase in thermopower with temperature up to a saturation value.

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Other Types of Organic Semiconductors

As with the inorganic types, the organic semiconductors are also characterized by the nature and type of the carrier which appears to dominate in the carrying of current. A material may be either *n*-type or *p*-type, for example. Among the organic dyes investigated, the cationic dyes appear to be *n*-type semiconductors and the anionic dyes *p*-type. (The cationic dyes can exist in two forms, one of which will induce photoconductivity in the glass substrate upon which it is laid.) The phthalocyanine molecule, which is much like the active center of several biologically-active compounds (e.g., chlorophyll), can accommodate a metallic atom at its center. These molecules' conductivities range from 10^{-10} to 10^{-11} reciprocal ohm-cm. Compressed pellets of phthalocyanine, if they contain traces of certain inorganic acids, have been observed to act as rectifiers, especially if placed between metallic electrodes of two different metals. Magnesium phthalocyanine, if coated with a layer of air-oxidized aromatic amine, has been observed to produce a photovoltage when illuminated. Analogous behavior has been observed in coronene and chloranil (*25, 26*). Such behavior may indeed be much like that in certain biological systems. A large number of semiconducting polymers of the polyacene quinone radical (PAQR) type have been prepared by the Friedel-Crafts reaction and studied. The conductivities range from 10^{-4} to 10^{-10} reciprocal ohm-cm, and the Seebeck coefficients (thermoelectric power) are positive, so far as examined, being about 100 to 300 μV/°K. The E values, as calculated from the slopes of the conductivity versus T^{-1} lines, range from 0.26 to 1.8 ev. These polymers were prepared from various reactive aromatic hydrocarbons (some bearing substituent groups) and the anhydrides of various aromatic acids. The PAQR polymers are observed to contain high concentrations of stable free radicals, and are therefore polyradicals. They are hard, black, and cross-linked, but show appreciable thermoplasticity. The electrical data exhibited by them demonstrates a good fit to the equations for an *intrinsic* semiconductor; the populations of carriers so indicated is about 10^{15}/cm^3, with mobilities of about 10^{-2}cm^2/v-sec, holes having a somewhat greater mobility than electron carriers. This is not to be taken to mean that these materials are intrinsic semiconductors in the strict terms of the band theory, but rather that, mathematically, a good fit can be obtained using such equations. Upon heating the PAQR polymers to elevated temperatures in an inert atmosphere, the conductivity at first falls sharply (*ca.* 400°C) and then increases rapidly to values characteristic of polymers (over 600°C). This shows that there is something unique and characteristically favorable to conduction in the original polymers and that they are not merely pyropolymers. Polymers of related structure, called xanthene polymers, and others comprising polydiketones appear to be semiconductors roughly equivalent in conductivity to the PAQR polymers. Ferrocene, which is a sandwich-type compound having an iron atom bound between two layers of hydrocarbon groups, is an insulator. Ferrocene resembles the lower aromatic hydrocarbons in many ways. If this molecule is attached to a vinyl group and made into a polymer, it is, like polystyrene, an insulator. Polymers formed from ferrocene molecules linked intermolecularly by CO groups (i.e., the polyketones) show limited semiconduction, ranging from 10^{-3} to 10^{-11} mho/cm, whereas linking them with benzal groups gives polymers with conductivities of 10^{-7} to 10^{-8} mho/cm. Polyphenyl, a linear chain of aromatic rings, shows a conductivity of about 10^{-10}; polytetrachlorophenylthioether has a conductivity of either 1 or 10^{-7} mho/cm, *depending upon the method of preparation.* The latter compound, if placed between silver and platinum electrodes, shows rectification. Work has been reported on a vulcanized aromatic hydrocarbon type of polymer made with sulfur and aromatic hydrocarbons which exhibits a conductivity of 10^{-4} mho/cm. Copper phthalocyanine polymers with extensive cross-linking have been found to have conductivities of 10^{-4} and 10^{-8} mho/cm. The conductivity is higher than that of the corresponding monomer (see above) and is a good illustration of the efficacy of polymerization in increasing electronic conductivity. Proteins in the dry state conduct slightly, but as in the case of albumin (10^{-21} mho/cm) may be insulators. In the wet state they conduct appreciably, and it was suggested that hydrogen-ion transfer may be involved (*42*).

It has been found possible to "dope" copper phthalocyanine polymers; the sign of the Hall coefficient is observed to change with an oxygen pressure greater than 490 mm Hg (see Table 2). Thus, conversion from *n*-type to *p*-type material and vice versa can be accomplished by changing the O_2 pressure. Qualitative adsorption studies made on the material at room temperature reveal the possibility of water vapor adsorption. Other supplementary additives or dopants, when purposely introduced either in the preparation of the compound or after the compound has been formed, can alter or modify the conductivity type and thermoelectric power. See Table 3.

Among the organic structures examined in the author's laboratory for semiconductor-like behavior have been derivatives, in stressed or "unusual" electronic states, of sandwich-compounds like ferrocene. Activation energies of 0.1 to 0.3 ev have been observed,

Table 2. Effect of O_2 Pressure on the Hall Coefficient

O_2 pressure (mm Hg)	R_H (cm^3/coulomb)
10^{-5}	−252
209	−103
414	− 39
490	0
775	+105
990	+241

Table 3. Effect of Doping on the Conductivity-type of the Polymer of Copper Phthalocyanine (Measured at 23°C)

Agent, treatment or preparation	Conductivity-type	Thermoelectric power μV/deg
None	*p*	12–18
Water vapor	*n*	59
H_2S	*n*	30
Bromine	*p*	1
Ozone	*p*	5
Polymer prepared with copper-deficiency	*n*	8
Polymer prepared with excess of copper	*p*	4
Heat-treated (irreversibly)	*p*	33–37

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with anisotropic conductivities in the range of that in organic semiconductors and that, in some cases, appear to observe the classical conductivity-temperature exponential relationship (*20*). In addition, a number of Hall-coefficient determinations were made and, in certain cases, highly-reproducible values were obtained. Recently (*31*) Mulay and Fox showed that on the basis of paramagnetic measurements of magnetic anisotropy the bonding in ferrocene is $d\pi$-$p\pi$ single metal-to-ring covalent bonding. Like benzene, the data supports "ring current" effects to explain anisotropy.

Conclusion

It is clear that the science has not yet progressed to the point where applications or devices using organic semiconductors can be fabricated, although rectifying contacts to organic semiconductors are well established. Thermoelectric applications can be mentioned in view of the low thermal conductivity of organic materials together with the demonstrated possibility of appreciable electric conductivity. Unfortunately these desirable properties are as yet accompanied by very low values of thermoelectric power. Many properties of these compounds are likely to depart from those familiar in inorganic semiconductor technology, which implies that different applications and devices will result (*10, 34*). In any event, the improved understanding of organic materials which results from this research, together with the development of new (particularly electrical) experimental measurement techniques, cannot fail to make substantial contributions to organic compound technology. It is well recognized that in the analogous situation the study of inorganic semiconductors has contributed much toward the appreciation of properties of other solids. The most remarkable thing about the current state of these investigations, however, is the frequent complete reversals of field in connection with current attempts to explain organic semiconduction, as new and apparently contradictory data appear. Lest the investigator become discouraged with such a state of affairs, it should be remembered that this is a stage through which most of the fruitful areas of study have passed. It is merely an indication that some experiments have not been carefully or fully performed and that many crucial and interesting experiments, rich in theoretical implications, have yet to be carried out.

If the high efficiencies of electron transfer processes now obtainable from the inorganic semiconductors can be attained with the organics (contingent, in all probability on a better theoretical understanding of the nature of these processes in organic compounds), it is possible that commercially attractive organic semiconductor devices may result. In addition, it may well be that the greatest contribution to human progress resulting from studies on organic semiconductors will be in contributions to our understanding of certain important biological processes, such as photosynthesis, initiation of photosensitive carcinogenesis, as well as processes involved in vision, which are strongly concerned with activated electron transfer in organic polymeric media (*48*). On the other hand, the added interpretations of electron-transfer processes which man could apply broadly may be most fruitful; the concepts and techniques of molecular engineering would then be applied to achieving optimum results in these materials. The possibilities we can now foresee for electronically-active polymers are many and varied. It now appears that certain semiconductive polymers have perhaps the highest known and stably-reproducible coefficient of resistance change with pressure. Use at high pressures and temperatures up to 800°C has been successful. Semiconducting polymers can be used as resistive elements having selected properties such as zero coefficient of resistance change with temperature, or a desired positive or negative change. Such polymers may potentially be useful as thermoelectric power sources. The polymeric semiconductors could be applied as anisotropic semiconductive coatings, as photovoltage sources, or possibly as photoelectric devices, for they change conductivity upon illumination. Photovoltaic cells made up of layers of magnesium phthalocyanine and air-oxidized tetramethyl *p*-phenylenediamine, or of coronene coated with a layer of *o*-chloranil, were investigated. More recently, considerable rectification was obtained from phthalocyanine layers confined by two differing metals and bearing traces of an acid. These rectifiers were operable at 60 cps and had excellent forward-to-reverse current ratios up to 500 cps. The action was proved to be electronic and not simply ionic, for long-continued passage of current did not change the conductivity. Organic materials are generally quite "ohmic" and show little change in resistance with electric field change until rather high fields are used. Among the other possible uses for organic semiconductors in electronics are as components of ferroelectric devices, of microphones, of parametric circuit elements, of hydromagnetic devices, cold-emission electrodes, or as information-storage components. It can also be suggested that semiconductive organics may find application as fuel-cell electrodes, phosphor-modifiers and coatings for color lighting, as semiconductive layers or films to heat surfaces or remove charges from them. One very promising outlook is for their use in electrically applied coatings. The possibilities seem almost as numerous as there are organic compounds.

Literature Cited

(1) Acker, D. S., Harder, R. J., Hertler, W. R., Mahler, W., Melby, L. R., Benson, R. E., and Mochel, W. E., *J. Am. Chem. Soc.*, **82**, 6408 (1960).
(2) Acker, D. S., and Hertler, W. R., *J. Am. Chem. Soc.*, **84**, 3370 (1962).
(3) Akamatsu, H., Inokuchi, H., and Matsunaga, Y., *Bull. Chem. Soc., Japan*, **29**, 213 (1956).
(4) Bergdahl, L. E., *J. Org. Chem.*, **25**, 1979–86 (1960).
(5) Brophy, J. J., and Buttrey, J. W., "Organic Semiconductors (ARF Conferences)," MacMillan Co., New York, 1962.
(6) Chesnut, D. B., Foster, H., and Phillips, W. D., *J. Chem. Phys.*, **34**, 684 (1961).
(7) Chesnut, D. B., and Phillips, W. D., *J. Chem. Phys.*, **35**, 1002 (1961).
(8) Craig, D. P., and Hobbins, P. O., *J. Chem. Soc.*, **1955**, 539, 2302, 2309.
(9) Davydov, A. S., *J. Exp. Theoret. Phys. (USSR)*, **18**, 210 (1948).
(10) Forchheimer, O. L., and Newkirk, T. F., *J. Chem. Educ.*, **38**, 183 (1961).
(11) Fox, D., *J. Phys. Chem. Solids*, **8**, 439 (1959).
(12) Fox, D., and Schnepp, O., *J. Chem. Phys.*, **23**, 767 (1955).
(13) Frenkel, J., *Phys. Rev.*, **37**, 17, 1276 (1931).
(14) Gatos, H. C., ed., "The Surface Chemistry of Metals and Semiconductors," John Wiley and Sons, Inc., New York, 1960.

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(15) Hannay, N. B., ed., "Semiconductors," Reinhold Publishing Corp., New York, 1959.
(16) Hertler, W. R., and Benson, R. E., *J. Am. Chem. Soc.*, 84, 3474 (1962).
(17) Hertler, W. R., Hartzler, H. D., Acker, D. S., and Benson, R. E., *J. Am. Chem. Soc.*, 84, 3387 (1962).
(18) Joffe, A. F., "Physics of Semiconductors," Academic Press, Inc., New York, 1960.
(19) Juster, N., J. Chem. Educ., 40, 489 (1963).
(20) Juster, N., unpublished research.
(21) Kallmann, H., and Pope, M., *J. Chem. Phys.*, 32, 300 (1960).
(22) Kallmann, H., and Silver, M., "Symposium on Electrical Conductivity in Organic Solids," Interscience Publishers, New York, 1961.
(23) Kepler, R. G., Bierstadt, P. E., and Merrifield, R. E., *Phys. Rev. Letters*, 5, 503 (1960).
(24) Kommandeur, J., and Hall, F. R., *Bull. Am. Phys. Soc.*, Series II, 4, 421 (1959), and *J. Chem. Phys.*, 34, 129 (1961).
(25) Kronick, P. L., and Labes, M. M., *J. Chem. Phys.*, 35, 2016 (1961).
(26) Labes, M. M., Sehr, R., and Bose, M., *J. Chem. Phys.*, 32, 1570 (1960), and 33, 868 (1960).
(27) Labes, M. M., Sehr, R., Bose, M., Ur, H., Wilhelm, F., Paper presented at the Duke Conference on Electronic Conductivity in Organic Solids, April, 1960.
(28) Lyons, L. E., *J. Chem. Soc.*, 1957, 5001.
(29) Lyons, L. E., Paper presented at the Duke Conference on Electronic Conductivity in Organic Solids, April, 1960.
(30) Melby, L. R., Harder, R. J., Hertler, W. R., Mahler, W., Benson, R. E., and Mochel, W. E., *J. Am. Chem. Soc.*, 84, 3374 (1962).
(31) Mulay, L. N., and Fox, M. E., *J. Am. Chem. Soc.*, 84, 1308 (1962); *Rev. Sci. Instr.*, 33, 119 (1962).
(32) Pocchettino, A., *Acad. Lin. Rendiconti*, 15 (1), 355 (1906).
(33) "Proceedings of the International Conference on Semiconductor Physics, Prague, 1960," Academic Press, New York, 1961.
(34) Scott, A. B., chr., "Chemistry of the Solid State," (Symposium), J. Chem. Educ., 38, 224–250 (1961).
(35) Slater, J. C., "Quantum Theory of Matter," McGraw-Hill Book Co., Inc., New York, 1951.
(36) Smith, R. A., "Semiconductors," Cambridge University Press, Cambridge, 1959.
(37) Sommerfeld, A., *Z. Physik.*, 47, 1 (1928).
(38) Vartan'yan, A. T., *Izv. Akad. Nauk, SSSR Ser. Fiz.*, 20, 1541 (1956).
(39) Volmer, M., *Ann. Physik.*, 40, 775 (1913).
(40) Wagner, C., and Schottky, W., *Z. physik. Chem.*, *B*11, 163 (1930).
(41) Wannier, G. H., *Phys. Rev.*, 52, 191 (1937).
(42) Weitz, E., and Schmidt, F., *Ber.*, 75, 1921 (1942).
(43) Williams, J. K., *J. Am. Chem. Soc.*, 84, 3478 (1962).
(44) Szent-Gyorgi, A., *Science*, 93, 609 (1941).
(45) Dewar, M. J. S., and Talati, A. M., *J. Am. Chem. Soc.*, 85, 1874 (1963).
(46) Mackintosh, A. R., *Scientific American*, 209, 110 (July 1963).
(47) Atlas, S. M., Becher, M., and Mark, H. F., *SPE Trans.*, 10, 169 (Oct. 1961).
(48) Kasha, M. and Pullman, B., editors, "Horizons in Biochemistry," Academic Press, New York, 1962, (*a*) Eley, D. D., pp. 341–80, and (*b*) Brillouin, L., pp. 295–318.

Chem Ed

LETTERS

To the Editor:

A confusion may arise from Dr. DeWolfe's differential rate equation (1) involving the thermodynamic activities instead of the concentrations (DeWolfe, R. H., this Journal 40, 95 (1963));

$$-d(C)/dt = k\, a_A{}^l a_B{}^m a_C{}^n \qquad (1)$$

If we define the activity as γC where C is the concentration and γ activity coefficient and if we restrict ourselves to ionic reactions in solution, this equation would predict that the rate of the reaction always would decrease upon increase in the ionic strength, since the Debye-Hückel theory predicts that

$$\gamma = f(\sqrt{\mu})$$

Actually, however, it has been observed that the rates decrease, increase, or are unaffected by the increase in the ionic strength. This can be explained in terms of the absolute reaction rate theory.

Referring to the literature,[1] we find the following rate equation for the simplest reaction;

$$A + B = AB\ddagger \rightarrow P$$

$$d(P)/dt = k'K\ddagger(A)\ \gamma_A\ (B)\ \gamma_B/\gamma_{AB}\ddagger = k\ a_A\ a_B/\gamma_{AB}\ddagger \qquad (2)$$

where

$$K\ddagger = (AB\ddagger)\ \gamma_{AB}{}^*/(A)\gamma_A\ (B)\ \gamma_B$$

and

$$k = k'K\ddagger$$

Equation (2) predicts correctly, in principle, that the rate will increase for the identical charge species of A and B because AB‡ will have a double charge which decreases $\gamma_{AB}\ddagger$ still more, and that the rate will decrease upon increase in the ionic strength, if A and B are oppositely charged. If A is charged but B is neutral molecule, the rate will not change upon adding salts (the so-called Livingston's fan).[2] The present argument is in principle applicable to any organic reactions in solution which proceed via ionic mechanisms.

Equation (1) will not anticipate the effect of the ionic strength on the rate of the ionic reactions in solution, which are common in organic chemistry, except on those cases in which the reacting species are of equal and opposite charge. The essential point in this argument would not be affected by the sign of the coefficients, l, m, and n.

Equation (2) based upon the application of the Debye-Hückel theory to predict γ's is offered as a more generally applicable expression. Further, the Debye-Hückel theory can predict the effect of the ionic strength on γ_A, γ_B, and $\gamma_{AB}\ddagger$ correctly with respect to the direction of the deviation from unity within the limit of approximation, as this limitation has been frequently applied to the solution reactions.

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[1] Glasstone, S., Laidler, K. J., and Eyring, H., "The Theory of Rate Processes," McGraw-Hill, New York, 1941, 401, 423–30.
[2] Benson, S. W., "The Foundations of Chemical Kinetics," McGraw-Hill, New York, 1960, p. 527, Fig. 5.

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William P. Ratchford[1] and
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More Wealth from Agriculture

Utilization research and development in the Agricultural Research Service of the U.S. Department of Agriculture is concerned with finding new and improved uses for farm products, so that profitable new markets for the farmer will be created and present markets expanded.

The four Utilization Research and Development Divisions—the Eastern at Wyndmoor, Pa., near Philadelphia; the Northern at Peoria, Ill.; the Southern at New Orleans, La., and the Western at Albany, Cal.—have a professional staff totaling about 850, mostly chemists, chemical engineers, food technologists, and microbiologists. Each Division operates a large regional laboratory and some Divisions have research personnel in field locations. Thus, the Eastern Division includes research scientists stationed in Washington, D. C., and Beltsville, Md. Figure 1 shows a typical installation of a modern research instrument. J. M. Purcell is shown adjusting the Eastern Division's NMR spectrometer.

Some of the accomplishments of utilization research were described in an earlier report entitled "New Wealth from Agriculture" (*1*). The present paper summarizes briefly some additional accomplishments that have created additional new wealth from agriculture.

Research in the Eastern Division Laboratory

The earlier report (*1*) described some of the Eastern Division's research program on animal fats. This program is continuing, and from it are coming new chemicals of importance in lubricants, detergents, plastics, and in other large-use industrial fields (*2*). The epoxy compounds, stemming from research on the epoxidation (*3*) of the fatty acids of animal and vegetable fats and oils, are widely used as plasticizers to give heat and light resistance to plastics.

These epoxy compounds are also found in nature. The oil in the seeds of the exotic ironweed plant (*Vernonia anthelmintica*) contains 70% epoxy acids. This plant is now being grown experimentally in many parts of the United States by agronomists, while Eastern Division scientists are studying the oil. If the industrial potential for the oil of this plant continues to develop (*4*), it may be cultivated domestically for industrial use and grown on acreages now devoted to the production of grains or other crops now in excess.

In addition to industrial products and processes utilization research seeks to develop new food products and to devise new and improved methods of making existing products. The Eastern Division has been assigned a number of important commodities used principally for food—milk, meat, eastern fruits and vegetables, maple sirup, and honey. Some of the products developed from these commodities have not only helped agriculture and industry, but have lightened the burden of the kitchen chores that must be done by the American housewife. Eastern Division engineers pioneered the development of a new way of dehydrating

Figure 1. NMR spectrometer at Eastern Division.

Presented before the 24th Summer Conference of NEACT, Amherst, Massachusetts, August, 1962.

[1] *Assistant Director, Eastern Utilization Research and Development Division, Agricultural Research Service, USDA, 600 E. Mermaid Lane, Philadelphia 18, Pennsylvania.*

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mashed potatoes (*5*). Now the product of this research—known as potato flakes—is being made by 12 American factories, and is available throughout the country. Potato flakes, potato granules, and other convenience potato products are restoring potatoes to the important place they once had in the American diet. The per capita consumption of potatoes had been on a downward trend for 50 years, but in the past few years has begun to climb again, and there seems little question that the phenomenal growth of processed potato products has been largely responsible—to the benefit of American potato growers.

A new and promising field of food dehydration now developing involves a technique called "explosion puffing" (*6*). Pieces of potato, carrot, beet, turnip, sweet potato, and apple can be prepared by this process. Conventional dehydration processes can also prepare foods like these, but dehydration is slow and 20 min to a half hour is required for cooking. Eastern Division engineers call the new product "quick-cooking dehydrated fruit and vegetable pieces," because they are ready to eat after 2–6 min simmering, depending on the product. These products are prepared by first partly dehydrating the pieces, then "exploding" them in a low-pressure chamber. The object is not to expand the pieces in size, but to put tiny channels in them by flashing off water vapor. When the pieces are returned to the drier, the rest of the water, which otherwise could be removed only by expensive and time-consuming methods, comes out quickly through these channels. When these dehydrated pieces are cooked, the water readily returns through the same channels. There are immense possibilities for these products. They may make an impact on the food industry such as potato flakes have already made.

The Northeastern and North Central States are especially interested in the paraformaldehyde pellets which were used commercially for the first time last season to disinfect maple tree tapholes (*7*). Years ago basic research on maple sap and sirup at the Eastern Division established the importance of sanitation in sap gathering and sirup production, in order to prevent the spread of quality-destroying microorganisms. Then it was discovered that microbial growth was responsible for the "drying up" of the taphole. Having established the real cause of this loss in the quantity and quality of maple sap, Eastern Division scientists gave the problem of preventing the growth to Michigan State University. The paraformaldehyde pellet developed there, which is simply inserted in the taphole at the beginning of the season, is credited with increasing sap yields by a third to a half in the 1962 season.

Some 30% of utilization research is to basic research. On potatoes, for example, while engineers are working out new dehydration methods, chemists are seeking exact knowledge of the composition of potatoes—knowledge that may provide the key to many processing difficulties that have been encountered. For example an automatic chromatography column is in operation 24 hrs a day, 7 days a week on the problem of amino acid content of potatoes.

Several lines of basic research on animal products, notably on milk and meat, are also being pursued. One study involves casein, the chief protein in milk. Casein is not homogeneous, but consists of at least three individual components, identified as α-, β-, and γ-casein. A calcium-sensitive fraction of α-casein can be identified; it is designated alpha$_s$-casein of milk (*8*) and can consist of three forms, A, B, and C.

Apparently, the genetic inheritance of the cow governs which ones occur in the milk of an individual cow. Since genes occur in pairs, a cow may yield one of six kinds of alpha$_s$-casein: alpha$_s$-AA, -AB, -AC, -BB, -BC, or -CC. This complexity of casein seems to be typical of other milk products as well. Figure 2 shows Dr. M. P. Thompson using the technique of zone electrolysis. This important experimental technique was responsible for revealing the genetic variation of casein.

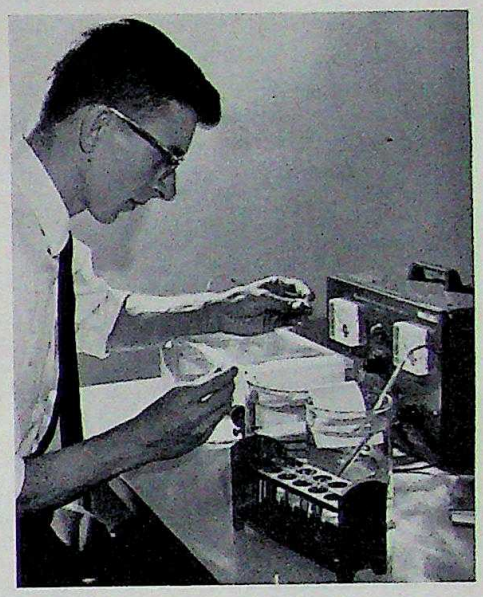

Figure 2. Zonal electrophoresis of milk proteins in starch gel.

Basic studies on meat have revealed that not all microbial lipases behave similarly toward meat fats. Thus at 35°C *Staphylococcus* lipase releases saturated C_{16} acids from lard much more rapidly than *Pseudomonas* or *Geotrichum* lipase. The low activity of *Pseudomonas* is apparently due to its low ability to attack the 2-position in the glyceride, whereas that of *Geotrichum* is apparently due to low ability to attack saturated fatty acids (*9*).

Leather is another product on which an active program of utilization research is maintained. Synthetic substitutes have cut deeply into the market for leather and threaten to cut still deeper. New methods of preparing hides for tannage and new tanning materials may lower the price and improve the usefulness.

Two promising new tanning materials have been found. One is dialdehyde starch which is especially attractive because scientists at the Northern Division devised a practical way of making it from corn. Using dialdehyde starch as a pretanning agent, fine sole leather can be made in a week, whereas normal sole leather tanning takes six times that long (*10*).

The other new tanning material is glutaraldehyde, which produces soft leather resistant to a variety of agents that deteriorate ordinary leather (*11*). Glutaraldehyde is already in use by some tanners to make high quality garment leathers from sheepskins and shoe upper leathers from cattle hides.

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The Southern Division is probably best known for its research on cotton and deserves a lot of credit for the remarkable comeback this versatile fiber has made in recent years in competition with the synthetic fibers. Southern Division scientists have now invented stretch cotton (*12*). Once at a disadvantage because of its lack of elasticity, cotton can now be made into yarns with plenty of stretch and fabrics with plenty of give. It is not hard to imagine the vast new fields for cotton.

While the New Orleans group is carving out new markets for cotton, utilization research scientists at the Western Division in Albany, Cal., have devised a way of overcoming a serious limitation of another excellent fiber, wool. This is shrinkproofing treatment that employs interfacial polymerization (*13*); it is called the Wurlan treatment (Fig. 3). A diamine (A) dissolved in water and a diacyl chloride (B) dissolved in a solvent that does not mix with water interact rapidly at room temperature at the interface between the two liquid solutions to form a colorless polymer film.

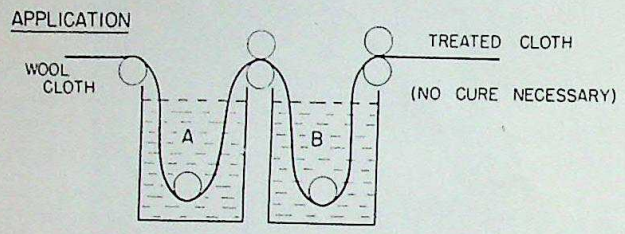

Figure 3. Principle of Wurlan treatment.

Continuous treatment of wool fabrics is accomplished by passing the fabric successively through the two solutions. Squeeze rolls remove excess liquid. After treatment the fabric is simply washed and dried. The ultra-thin polymer film is permanently anchored to the wool fibers and gives durable shrink resistance to machine laundering. A treated piece is practically identical in appearance, dimension, and feel to an unwashed piece, even after four 75-min washings. One 75-min washing badly shrinks an untreated sample.

The scientists at the Northern Division have found uses for surplus grains other than dialdehyde starch. An example is kraft paper containing up to 45% cereal starch xanthide or cereal flour xanthide, used as an additive with unbleached kraft wood pulp. It has up to nine times the wet strength and nearly three times the endurance of ordinary kraft paper (*14*). Moreover, the wet strength may be considered permanent, since it is not significantly changed when the paper is soaked for 24 hrs. Preparation of cereal pulps by a xanthation process followed by cross-linking has made possible the first use of grains as an integral part of paper. If this development opens up the vast paper industry as a market for grains, it will be an important contribution to our agricultural economy.

Literature Cited

(1) Ratchford, W. P., J. Chem. Educ., **32**, 160–2 (1955).
(2) Ault, W. C., *Chem. Ind.*, **1960**, 476–9.
(3) Findley, T. W., Swern, D., and Scanlan, J. T., *J. Am. Chem. Soc.*, **67**, 412–14 (1945).
(4) Riser, G. R., Hunter, J. J., Ard, J. S., and Witnauer, L. P., *J. Am. Oil Chem. Soc.*, **39**, 266–8 (1962).
(5) Cording, J., Jr., Willard, M. J., Jr., Eskew, R. K., and Sullivan, J. F., *Food Tech.*, **11**, 236–40 (1957).
(6) Eisenhardt, N. H., Cording, J., Jr., Eskew, R. K., and Sullivan, J. F., *Food Tech.*, **16**, 143–6 (1962).
(7) Costilow, R. N., Robbins, P. W., Simmons, R. J., and Willits, C. O., *Michigan Quart. Bull.*, **44**, 559–79 (1962).
(8) Thompson, M. P., Kiddy, C. A., Pepper, L., and Zittle, C. A., *Nature*, **195**, 1001–2 (1962).
(9) Alford, J. A., Elliott, L. E., Hornstein, I., and Crowe, P. F., *J. Food Science*, **26**, 234–8 (1961).
(10) Beebe, C. W., Happich, M. L., Naghski, J., and Windus, W., "Rapid Tannage of Sole Leather," U. S. Patent 3,027,-221, March 27, 1962.
(11) Filachione, E. M., Fein, M. L., Harris, E. H., Luvisi, F. P., Korn, A. H., Windus, W., and Naghski, J., *J. American Leather Chemists Association*, **54**, 668–79 (1959).
(12) *Agricultural Research*, January, 1962, **10**, No. 7, 10.
(13) Whitfield, R. E., Miller, L. A., and Wasley, W. L., *Textile Research Journal*, **31**, 704–12 (1961).
(14) Russell, C. R., Buchanan, R. A., Rist, C. E., Hofreiter, B. T., and Ernst, A. J., *Tappi*, **45**, 557–66 (1962).

An Inverted Mirror Image

An interesting puzzle can be presented by printing near the top of a blank card in red letters

CHECKED OK

while printing near the bottom of the card

NOT RIGHT

in blue letters.

A glass stirring rod (*not* glass tubing) is placed over the red printing and raised slightly so the printing may be viewed conveniently. Under these circumstances, the printing comes though without apparent distortion. When the blue printing is viewed in a similar manner, the printing appears quite garbled. Incorrect but ingenious explanations are given by the uninitiated to explain this effect. One such explanation is that the effect results from the difference in the wavelengths for the two separate colors. The correct explanation is that the glass rod transmits the original image in the form of an inverted mirror image. The inverted mirror image of only a few letters appears undistorted. These letters are all symmetrical about a horizontal axis.

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Chem Ed

BOOK REVIEWS

Advances in Heterocyclic Chemistry. Volume 1

Edited by *A. R. Katritzky*, University Chemical Laboratory, Cambridge, England. Academic Press, Inc., New York, 1963. xi + 476 pp. Figs. and tables. 16 × 23.5 cm. $15.

The conventional, comprehensive surveys of heterocyclic chemistry, such as the Elderfield (Wiley) and Weissberger (Interscience) series, are prepared (perhaps among others) under two inherent handicaps. First, there is a considerable time lag between the publication of the first volume of a series and that of the last. By the time the series is complete (if ever), the early volumes are sadly out of date. Second, in order to follow the usual, desirable organization by type of heterocycle and to maintain an economical size, the intercomparison of different heterocyclic series is rather minimal. The present new series of "Advances" promises to correct, at least in part, both of these deficiencies. The series contains both review articles bringing up to date the earlier Elderfield or Weissberger surveys and articles of a comparative nature cutting across whole classes of heterocyclic compounds. Although this approach is not new in isolated reviews, its systematic application promises to be of considerable value in the increasingly difficult struggle of the organic chemist to keep up with the developments in this broad and complex field.

In the present volume are two chapters bringing up to date earlier reviews: Recent Advances in the Chemistry of Thiophenes by S. Gronowitz and Quinazolines by W. L. F. Armarego. Also of a general review nature but encompassing several heterocyclic types is the chapter, Aza Analogs of Pyrimidine and Purine Bases of Nucleic Acids by J. Gut. The remaining chapters survey reactions or structural characteristics common to several heterocyclic series and include: Reactions of Acetylenecarboxylic Acids and Their Esters with Nitrogen-Containing Heterocyclic Compounds by R. M. Acheson, Heterocyclic Pseudo Bases by D. Beke, and two chapters on Prototropic Tautomerism of Heteroaromatic Compounds by Editor A. R. Katritzky and J. M. Lagowski. Written by authorities in their respective subfields who have contributed heavily to recent developments in heterocyclic chemistry, these chapters constitute an admirable selection of topics of considerable current interest not only to heterocyclic chemists but also to organic chemists in general. The chapters by Gronowitz and by Katritzky and Lagowski (and to only a slightly lesser extent the other chapters) illustrate very well the application of physical organic methods to heterocyclic chemistry and should be of interest to all organic chemists. Indeed, all of the chapters are characterized by a fresh, contemporary approach not always found in heterocyclic work.

The selection of topics for the volume is sufficiently clever as to cause one to wonder whether or not subsequent volumes can continue to present reviews of like interest. This question is answered in part by inclusion of a list of the contents of Volume 2, where, on the whole, the continuation of the high level of Volume 1 appears to be reasonably well assured by the stature of the contributors and the selection of topics.

One may argue, of course, that there is no positive assurance that a review by an expert in the field will necessarily be better than one by an abler author of lesser technical achievements. Furthermore, as articles in heterocyclic chemistry become less descriptive and more interpretative in nature, as is the present trend, there may be a tendency for the expert to present *his* interpretation and to depreciate the results or interpretations of others. Happily, the present volume seems to be essentially free of biased interpretations, and only rarely does the choice of examples or data and the evaluation of the results of other workers appear to be somewhat more subjective than objective. Furthermore, the reviews are well written, apparently aimed at a level intermediate between that of the rank novice and the expert in the field. The text is well organized for the reading of an entire chapter or the selective sampling for information on specific topics. This reviewer found no significant errors (except for a few of the inevitable typographical sort). The coverage of the various topics is extensive but not exhaustive. Thus, the reviews will serve as excellent introductions to or points of departure for the intensive study of a given area but not as substitutes for the reading of the original literature.

For many libraries (as well as individuals) the decision as to which, if any, books in a specialized field should be purchased with limited funds is a difficult one. To this reviewer it appears that no organic chemistry library of any but the most fragmentary sort can be assembled without at least one of the basic heterocyclic series (most of the experts in the field prefer the generally excellent and authoritative Weissberger series) and this new series of Advances. Certainly all chemists working in the heterocyclic field will require access to this series and organic chemists in other specialties will find much of general interest here.

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Reviewed in this Issue

A. R. Katritzky, editor, Advances in Herocyclic Chemistry. Volume 1
G. Brooks King and *William E. Caldwell*, College Chemistry
Louis Meites, Handbook of Analytical Chemistry
Frank J. Welcher, editor, Standard Methods of Chemical Analysis. Volumes 2A and 2B
G. Charlot, J. Badoz-Lambling, and *B. Tremillon*, Electrochemical Reactions
Giulio Milazzo, editor, Electrochemistry
Alexander Gero, Textbook of Organic Chemistry
John W. Sulcoski, Seimimicro Experiments in Chemistry
B. W. V. Hawes and *N. H. Davies*, Calculations in Physical Chemistry
Veniamin G. Levich, Physicochemical Hydrodynamics
Therald Moeller, The Chemistry of the Lanthanides
Paul Pascal, editor, Nouveau Traité de Chemie Minérale. Volume 9
Paul Pascal, editor, Nouveau traite de Chemie Minerale. Volume 8
Eric E. Conn and *P. K. Stumpf*, Outlines of Biochemistry
Harold Varley, Practical Clinical Biochemistry
H. H. Hausner, editor, Modern Materials: Advances in Development and Applications. Volume 3
Harry Sobotka, editor, Advances in Clinical Chemistry. Volume 5
David Glick, editor, Methods of Biochemical Analysis. Volume 11

College Chemistry

G. Brooks King, Washington State University, Pullman, and *William E. Caldwell*, Oregon State University, Corvallis. 4th ed. American Book Co., New York, 1963. viii + 637 pp. Figs. and tables. 16 × 24 cm. $7.25.

Those who liked the third edition of this well-known text will also like the fourth edition. There are no radical changes, but some improvements and additions. Atomic weights are now based on Carbon-12, a change—as the authors note (p 25)—"not particularly significant for beginning

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chemistry students." Some of the chapters have been rearranged and new material is presented on chemical bonding, complex ion formation, coordination compounds, bond orientation and bond types. There is no reference to thermodynamic terms such as entropy, enthalpy or free energy. A chapter on transition elements has been added. The type has been reset, and some of the figures redrawn with some improvement in the appearance of the book. Perhaps a third of the exercises in the third edition have been replaced with new ones. A Bibliography replaces the References of the former edition.

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Handbook of Analytical Chemistry

Louis Meites, Polytechnic Institute of Brooklyn, New York. McGraw-Hill Book Co., Inc., New York, 1963. xv + 1806 pp. Tables. 16 × 23.5 cm. $47.50.

It is not often that a new book represents a substantial achievement in the field of chemistry. The compilation of the "Handbood of Analytical Chemistry" by Louis Meites, however, is truly one of outstanding efforts in the recent years. This new work has some features in common with the handbooks of chemistry and physics that have been published for some time. However, this, new *analytical* handbook has the unique advantage of containing short discussions of the material in each table of data. Inclusion of references and features such as the precision of different analytical determinations makes this book extremely valuable to the practicing analyst.

One is hard pressed to find any topic of analytical importance omitted. Illustration of the scope of the reference may be seen in the treatment of topics such as the analyses of elastomers, pesticides, fertilizers, paints, pharmaceuticals, plastic and resin soaps, water and sewage. This section designated "applied" analysis also has a thorough referencing of the conventionally treated subjects such as coals, mineral petroleum products and alloys.

The extent of coverage, however, varies greatly from one topic to another. This is illustrated by the fact that the portion dealing with fundamental analysis has extremely large and complete sections on functional group analysis, chelometric titrations and polarography. Topics such as conductometric titrations and chronopotentiometry constitute a minor but adequate portion.

This reviewer feels that Professor Meites has consolidated a library-full of references to analytical and physical data into a well-indexed and referenced volume. The one-hundred and thirty authors, including Professor Meites, who himself wrote a substantial portion of the book, deserve special recognition for a difficult job well done. The price, $47.50, may cause many to pause before deciding whether or not to buy this book. (And unfortunately the binding is not of a quality commensurate with the price.) I feel, however, that no chemistry library or laboratory can afford to be without this outstanding handbook.

THEODORE R. WILLIAMS
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Standard Methods of Chemical Analysis. Volumes 2A and 2B, Industrial and Natural Products and Noninstrumental Methods

Edited by *Frank J. Welcher*, Indiana University, Bloomington. 6th ed. D. Van Nostrand Co., Inc., Princeton, New Jersey, 1963. 2613 pp. Figs. and tables. 16 × 23.5 cm. $25 each (not sold separately).

Volume 2 is divided into Parts A and B, bound separately. Part I of Part A comprises a new section of some 500 pages on apparatus, general operations, and reagents. Among chapters not included in the previous edition are qualitative analysis, separations (precipitation, extraction, chromatography, ion exchange, etc.), use of the microscope, quantitative microchemical analysis, and quantitative organic analysis. With the exception of the chapters on detection of cations and anions and on precipitation by change of hydrogen ion concentration, which are quite out of date, the new chapters are much more extensive and up to date than the older chapters. Altogether, the treatment of general topics in Part I of Part A is useful, but analytical chemists in general will prefer to consult more comprehensive accounts, such as monographs, that they already are likely to have at hand.

Part II deals with the analysis of industrial products and special samples, including, among others, air pollutants, alloys, bituminous materials, cement and coal. There is a section on chemical analysis in clinical medicine. Methods of analysis of industrial materials are continued in Part B, with chapters on explosives, fats, fertilizers, paint, paper, pesticides, petroleum, plastics, rubber, silicates, soap, soils, vitamins, water, and other materials. Some of these chapters are new and others have been enlarged to include analytical advances in the quarter century which has elapsed since the 5th edition was published. A number of chapters do not offer adequate literature references, several of the new chapters are much more satisfactory in this respect and also, in general, are more up to date than the older ones. Few modern physicochemical methods of analysis are described.

In spite of these limitations, anyone confronted with analysis of commercial materials will wish to consult this work and, more likely than not, follow its procedures. The strong feature of "Standard Methods" has been, and is, its explicit and detailed presentation of information for the analyst. The whole work is directed to the practical, technical analyst.

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Electrochemical Reactions: The Electrochemical Methods of Analysis

G. Charlot, Faculté des Sciences, Paris, *J. Badoz-Lambling*, Centre National de la Recherche Scientifique, Paris, and *B. Trémillon*, École de Physique et de Chimie Industrielles, Paris. American Elsevier Publishing Co., New York, 1963. ix + 376 pp. Figs. and tables. 17.5 × 24 cm. $15.

This text is a translation of a section of the French text "Les Méthodes de la Chimie Analytique." Charlot has written several books on specialized subjects and then combined them into a larger work. In 1959 he published his text "Les Électrochimiques," which was well documented to include references up to 1958. This work was combined with references on spectra and the analysis of elements to yield a large work, "Les Méthodes de la Chimie Analytique," which was published in 1961. The translation was made without any updating of the 1959 text.

The approach used is to introduce general concepts of electrochemistry, making great use of current-voltage diagrams and then attempting to show the relationship of this material to the various specialized areas of electrochemistry. The material is treated in a classical, much less rigorous manner than Delahay's "Modern Methods of Electrochemistry."

There are sections dealing with topics such as non-aqueous solvents, chronopotentiometry, the relationship between amperometry and potentiometry. The sections are very well referenced. Applications of electrochemistry are not treated in great detail.

This should be quite useful to teachers and may be suitable for use at the first year graduate school level. This text merits the attention of those persons interested in electrochemistry.

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Electrochemistry: Theoretical Principles and Practical Applications

Edited by *Giulio Milazzo*, Instituto Superiore di Sanità, Rome. Translated by *P. J. Mill*. American Elsevier Publishing Co., Inc., New York, 1963. xv + 708 pp. Figs. and tables. 15.5 × 23 cm. $20.

Despite the substantial increase in interest in electrochemistry as a whole throughout the United States, very few textbooks on electrochemistry have appeared in English during the past 10 years. The English revised edition of Professor Giulio Milazzo's textbook which appeared earlier in Italian and German editions is particularly welcome at this time.

The first six chapters of the book are concerned with the more fundamental aspects of electrochemistry. The first chapter presents a concise summary of thermodynamics with emphasis on those aspects which are important to the subsequent applications of thermodynamics to electrochemistry. Electrolytes and elec-

(*Continued on page A821*).

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NEW AP BOOKS

High Pressure Physics and Chemistry

Edited by R. S. BRADLEY
Volume 1, October 1963, 458 pp., $15.50
Volume 2, October 1963, 375 pp., $12.50

This treatise provides a comprehensive and advanced study of high pressure science, including both theoretical and experimental work on the production and measurement of static and dynamic high pressures. The gaseous, liquid, and solid states are considered in detail, together with discussions on equations of state, phase equilibria, and transport properties.

The Enzymes

Edited by PAUL D. BOYER, HENRY LARDY, and KARL MYRBÄCK
Volume 8, October 1963, about 475 pp., approx. $16.00
* Subscription price, about $13.60

Volume 8 includes coverage of various porphyrin enzymes, of other oxidases, and of direct oxygenation. The multiplicity of function of the porphyrin structure, as exemplified by enzymes discussed in this volume, is one of the many remarkable features of enzymology.

Diuretics
Chemistry and Pharmacology

By GEORGE deSTEVENS
Fall 1963, about 175 pp., approx. $6.50

The initial chapter of this book is concerned with the physiology of the kidney and the pharmacological methods by which substances are evaluated for their diuretic effects. It sets the stage for subsequent chapters dealing with the chemistry of these compounds and their structure-activity relationships.

Comparative Biochemistry

A Comprehensive Treatise
Edited by MARCEL FLORKIN and HOWARD S. MASON
Volume 6, September 1963, about 475 pp., $20.00
* Subscription price, $18.00

Volume 6 is devoted to chemical views on a number of biological concepts, all of them concerning the level of the complex architecture of cells and organisms.

Newer Methods of Preparative Organic Chemistry

Edited by WILHELM FOERST
Volume 2 translated by F. K. Kirchner
1963, 417 pp., $14.50
Volume 3 translated by Henry Birnbaum
Fall 1963, about 550 pp., approx. $19.00

This work provides a comprehensive survey of the latest developments in selected areas of preparative organic chemistry, filling the need for reviews and summarizations of the work done and suggesting those areas in which more intensive work is needed. References to the original literature and numerous tables are provided.

Metabolic Inhibitors

A Comprehensive Treatise in Two Volumes
Edited by R. H. HOCHSTER and J. H. QUASTEL
Volume 2, Fall 1963, about 675 pp., approx. $26.00
* Subscription price $22.00

The treatise stresses the results of research which shed new light on many biological processes and yield steadily increasing practical applications in such fields as medicine, pharmacology, and agriculture.

On the Primary Processes in Photosynthesis

Physical and Photochemical Aspects, Including a Short Guide to Systematics
By MARTIN D. KAMEN
Volume 1: Part A of Advanced Biochemistry: *A Series of Monographs*
Edited by ANTHONY SAN PIETRO
Fall 1963, about 200 pp., approx. $5.50

This unique work explains the rationales of modern researches into the primary processes of photosynthesis which terminate before the onset of biochemical and physiological phases. The bases of physical and photochemical investigations on the photosynthetic apparatus are presented and illustrated by examples from recent literature.

Chemical Applications of Infrared Spectroscopy

By C. N. R. RAO
Fall 1963, about 625 pp., approx. $20.00

This new book, on one of the most powerful techniques available for chemical analysis, presents the basic concepts, measurements, and techniques of infrared spectroscopy.

Modern Polarographic Methods

by HELMUT SCHMIDT and MARK VON STACKELBERG
Translated from the German by R. E. W. Maddison
1963, 99 pp., $5.50

Recent developments in polarography, a specialized branch of electro-chemistry, are summarized and reviewed in this new work. The advantages and disadvantages of new procedures, as well as their significance for chemical analysis and the resolution of scientific problems, provide a working theme.

Ultracentrifugal Analysis in Theory and Experiment

Proceedings of a Conference Sponsored by the National Academy of Sciences
Edited by J. W. WILLIAMS
1963, 282 pp., $10.00

Concentrating on three basic areas, transport theory, sedimentation equilibrium theory, and actual practice, twenty experts in the subject examine the efforts to solve the outstanding mathematical and operational problems inherent in ultracentrifugal analysis, and the possible use of the ultracentrifuge in biological and medical research.

Microscopic Characters of Artificial Inorganic Solid Substances

Third Edition
By ALEXANDER NEWTON WINCHELL and HORACE WINCHELL
Fall 1963, approx. 325 pp.

The book presents available data on and a graphic summary of the optical properties of inorganic solids, and a reference to readily available X-ray Powder Data of the substances described.

** Subscription price valid on orders for the complete set received before publication of the last volume.*

Detailed information available upon request.

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WILEY BOOKS

CHEMISTRY

A Survey of Principles

By GALEN W. EWING *and* E. GERALD MEYER, *Professors of Chemistry, New Mexico Highlands University.*

This book presents the fundamental principles of chemistry by selecting representative concepts, systems, substances, and reactions from present-day chemistry and treating them in depth. It develops the basic theory and provides a general description of such important topics as biochemistry, organic reaction mechanisms, thermodynamics, chemical equilibrium and reactions, and metal-organic and metal-inorganic complexes. The interaction between theory and experiment is emphasized consistently.

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This text is designed for one-semester chemistry courses for non-majors, and has high-school algebra as its *only* prerequisite. *1963. 239 pages. $4.95.*

PHYSICAL ORGANIC CHEMISTRY

By KENNETH B. WIBERG, *Professor of Chemistry, Yale University.*

The trend in most books on physical organic chemistry has been to stress the organic *chemical* aspects of the subject. This new text, however, concentrates more on the *physical* chemical aspects—and emphasizes the application of the methods of physical chemistry to the study of organic chemical phenomena. *Physical Organic Chemistry* is divided into three parts: Bonding and Spectra—Equilibria—Kinetics. These are given far more complete coverage than that offered by comparable texts. Throughout the book, specific examples are introduced that show how the material presented may be applied to the study of organic compounds. The highly useful appendix contains a review of matrix algebra, tables of constants and other numerical data, and additional important, related information. It features a discussion of computer programming—an area increasingly important to organic chemists. *1963. Approx. 600 pages. Prob. $10.75.*

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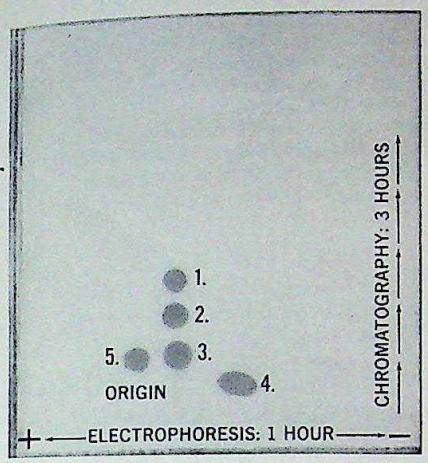

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trolytic conductance are treated effectively in the second chapter, although the material presented in this chapter does not go much beyond that found in many of the more complete undergraduate physical chemistry textbooks. The third chapter on galvanic cells provides a reasonably comprehensive discussion of the thermodynamics of electrochemical cells. A well organized introduction to electrochemical kinetics is presented in the fourth chapter although very little information is included on experimental methods for the study of electrochemical kinetics. Chapter 5 is concerned with analytical applications and includes sections on electrolytic analysis, potentiometry, conductance methods, and polarographic and voltammetric methods. Chapter 6 gives a brief introduction to the fundamental aspects of colloid chemistry and then discusses some of the analytical and industrial applications for electrophoresis and electrokinetic phenomena.

With the exception of Chapter 12 on the electrochemistry of gases the remainder of the book is concerned primarily with industrial applications including electrodeposition, electrorefining, industrial electrolysis, batteries, and corrosion. The chapters on the applied aspects of electrochemistry are primarily descriptive but not excessively technological in nature. In most instances only a broad survey of the field of application is presented.

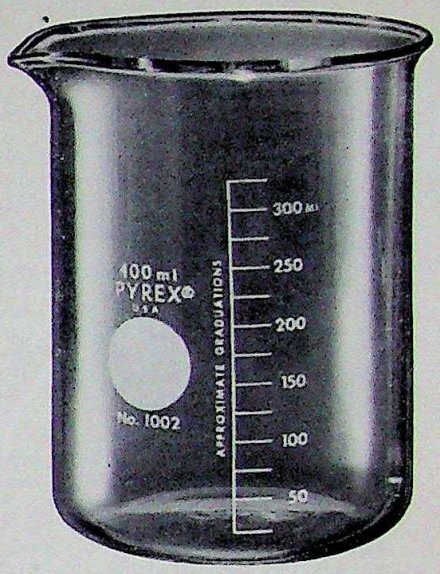
Four of the twelve chapters in this text are co-authored by other European electrochemists. Continuity, however, has been preserved between all of the chapters. The book as a whole is well organized and the presentation of complex ideas and concepts quite easy to follow. Dr. P. J. Mill who translated this new English edition from the Italian manuscript is to be commended for his translation.

Particular features of the book which are noteworthy are its numerous tables of data based on recent literature and the list of symbols and their definitions which appear in the beginning of the book.

This book is intended primarily to serve the function of a teaching textbook and is suitable for an upper undergraduate or beginning graduate level course in electrochemistry. An undergraduate course in physical chemistry emphasizing thermodynamics is a prerequisite. Since very few courses in electrochemistry are offered at any level in colleges and universities in the U.S. it is questionable whether the book will find wide use as a textbook for college courses in this country. Furthermore, no problems are provided in the book. For physical chemistry courses at both the undergraduate and graduate however, this book represents worthwhile collateral reading.

The recommendations of the IUPAC nomenclature commission are followed throughout the book relative to sign conventions as well as nomenclature. This may cause students using the book for collateral reading in courses in physical chemistry some difficulty, since the physical chemistry textbooks in this country generally have not adopted the IUPAC recommendations on nomenclature in the

(*Continued on page A823*)



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By CORWIN HANSCH, Pomona College, and GEORGE HELMKAMP, University of California at Riverside. Off press.

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By R. BRUCE MARTIN, University of Virginia. Modern Biology Series. Available in January.

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BOOK REVIEWS

(*Continued from page A821*)

fields of thermodynamics or electrochemistry.

ERNEST YEAGER
Western Reserve University
Cleveland, Ohio

Textbook of Organic Chemistry

Alexander Gero, Hahnemann Medical College, Philadelphia. John Wiley and Sons, Inc., New York, 1963. ix + 679 pp. Figs. and tables. 17.5 × 24.5 cm. $0000

Recent years have seen the inclusion of increasing amounts of material on reaction mechanisms in the elementary organic chemistry course, a trend with which this reviewer is wholeheartedly in favor. At least two excellent texts stressing this approach—Cram and Hammond, and Morrison and Boyd—have already appeared. Another—Roberts and Caserio—is waiting in the wings. Judged in such company, the present volume, which also attempts a modern approach to organic chemistry, comes off rather poorly indeed. In fact much of its presentation of "mechanisms" will give a physical-organic chemist pause.

First of all, except for isolated spots, the book generally ignores the most basic premise of all mechanistic considerations relative to the effect of structure on reactivity, namely, that the rate of an organic reaction is determined by the energy (or more accurately, free energy) difference between reactants and transition state. Instead it chooses to attempt to explain structure-rate effects almost entirely on the basis of differences in ground state energies of reactants, a procedure which is theoretically incorrect, and despite the fact it often leads fortuitously to correct predictions, is pedagogically indefensible, particularly in the elementary course, which represents the critical formative period of a student's basic approach to organic chemistry.

Second, the following peculiar statement relative to the canonical forms of a resonance hybrid occurs on p. 64: "The course of its [a compound's] reactions, however, may be determined more by the higher-energy canonical structures because the principal structure with its lower energy is less likely to be responsible for change than the more unstable, higher-energy canonical structures." This extremely questionable statement then proceeds to attain the status of a first principle and is employed repeatedly in the remainder of the book, as the supposed mechanistic explanation for various phenomena.

Some typical examples of the types of errors that occur throughout the book and that detract seriously from its treatment of reaction mechanisms are: On p. 81 in discussing the acidity of cyclopentadiene the statement is made that the cyclopentadienyl anion is more stable than cyclopentadiene. If this were literally true cyclopentadiene would have a K_a greater than unity, which, of course is not true. On p. 106 there occurs an obviously incor-

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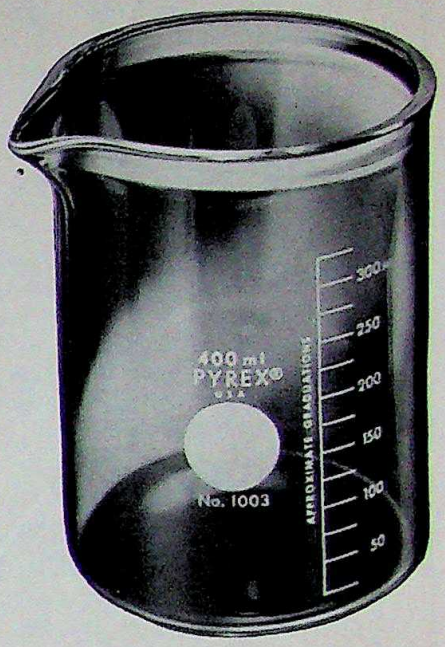

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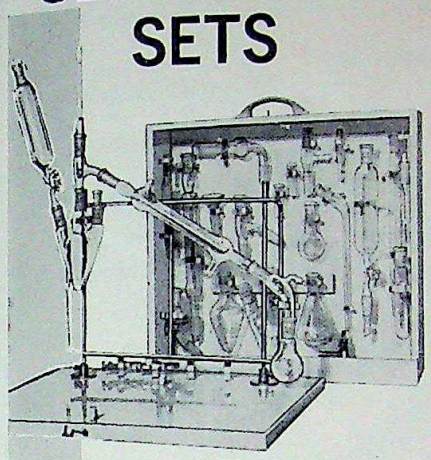

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rect explanation of the mechanism of the disproportionation of alkylbenzenes. On p. 191 it is strongly implied that tertiary alkyl halides do not undergo E2 elimination when in actual fact these halides undergo such eliminations much more readily than secondary or primary halides. On p. 207 in sec. 7.12 and p. 275 in sec. 10.20 occur two of the many (at least 20) examples of the application of the unusual postulate, referred to earlier, about reactions involving the most unstable canonical forms of a resonance hybrid. On p. 274 the failure of most ketones to form bisulfite addition compounds is ascribed to a rate phenomenon rather than to the fact the over-all equilibrium is unfavorable.

A further general criticism of the book's treatment of mechanism is that it gives much too little emphasis to the very considerable role which steric effects play in a wide range of organic reactions.

It is a pity that the treatment of reaction mechanisms comes off so poorly, for the treatment of descriptive organic chemistry is generally good, and the book as a whole is quite readably written. It also has the feature of providing unusually detailed coverage of heterocycles, and quite extensive coverage of other biologically or pharmaceutically important compounds. Treatment of stereochemistry varies from excellent in the chapter dealing with ring strain and geometrical isomerism (Chap. 4) to acceptable in that (Chap. 9) dealing with optical isomerism.

However, because of the shortcomings of the book's treatment of mechanisms and because this material is so extensive, and so interwoven with the rest of the text that it cannot be overlooked or omitted, this reviewer regretfully cannot recommend adoption of Gero's book as an elementary organic text.

JOHN L. KICE
Oregon State University
Corvallis

Semimicro Experiments in Chemistry

John W. Sulcoski, Dallas Senior High School, Dallas, Pennsylvania. Burgess Publishing Co., Minneapolis, 1963. viii + 128 pp. Figs. and tables. 21.5 × 27.5 cm. Paperbound. $2.90.

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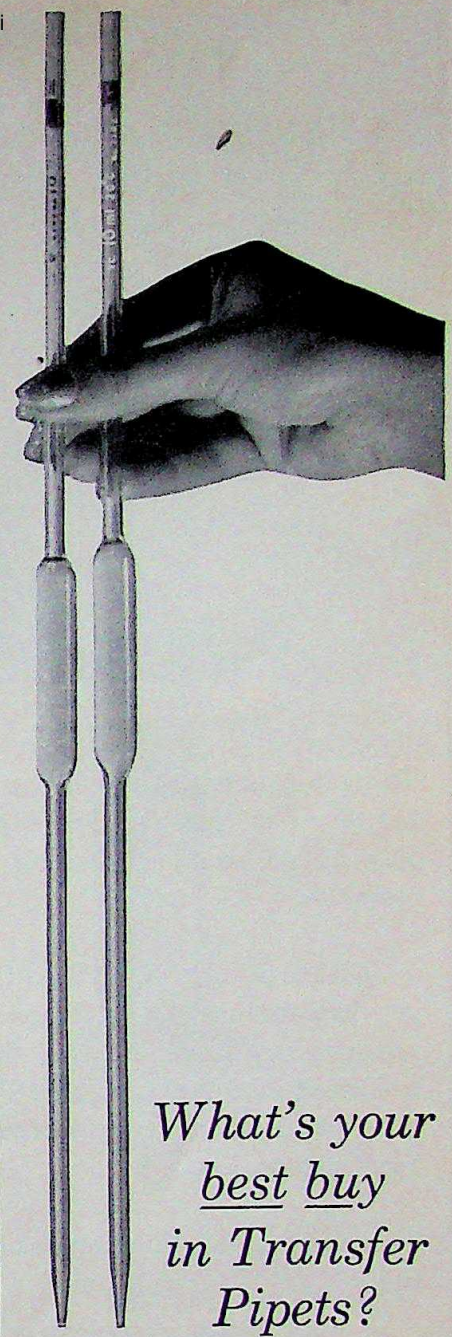

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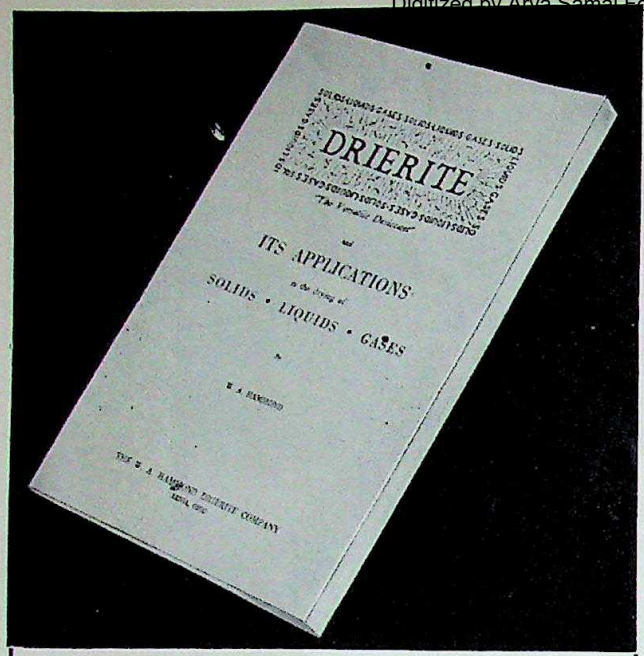

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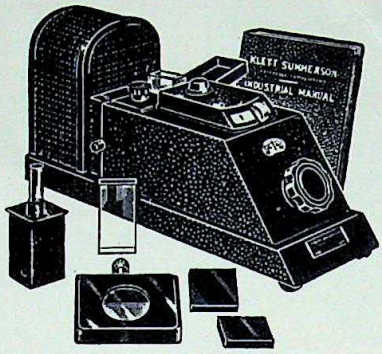

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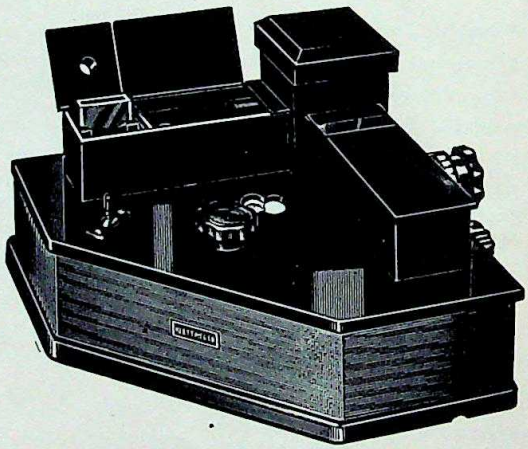

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observation. The student report includes a series of essay questions which require careful observation and interpretation of data. It is also suggested that the student report include equations for all the reactions involved.

The experiments are a little more sophisticated than those found in the usual high school laboratory manual. Excellent suggestions are contained in the teacher's manual. These include a general commentary on each experiment, lists of chemicals for each experiment, a quantitative list of chemicals needed for the entire course, apparatus list for the student locker and additional equipment needed in the laboratory. A list of stock solutions and their preparation is also included. There are suggested reference books and a short listing of suppliers for chemicals and equipment.

All the laboratory equipment is pictured. The manual suggests using semimicro equipment for the investigations although this would not be necessary. The introductory experiment on laboratory techniques appears to be very well written and easily followed by the beginner.

The author should be complimented for his effort to improve upon the laboratory instruction in the high school.

WILLIAM SCHREINER
Parma City Schools
Parma, Ohio

Calculations in Physical Chemistry

B. W. V. Hawes and *N. H. Davies.* John Wiley and Sons, Inc., New York, 1962. xiv + 203 pp. Tables. 14 × 21 cm. $4.50.

This little book covers the areas of classical physical chemistry as well as having chapters on Atomic Physics and Nuclear Chemistry and Molecular Structure. Each chapter consists of a series of problems with notes given to guide the student in solving them. The result will give the student practice in the manipulation of chemical calculations but does not serve too well in giving him a better insight into the theory behind the problem, so that he can later tackle the non-standard problems he may face. Answers for all problems are given at the end of the book.

The problems are for the most part fairly straightforward and routine, and do not involve extensive calculations, graphical integrations, etc., which are often encountered in practice. The book was designed to give British students practice for the various examinations that are a part of the British educational system. Many of the problems are actually taken from previous examinations.

Regretably the authors have not recalculated data to conform to the ^{12}C = 12.0000 atomic mass scale. They also have not been consistent in their conventions of cell potentials and use both oxidation and reduction half-cell potentials rather than changing them to conform to recommendations of the Stockholm convention.

This book should serve as a useful source of the type of question which tests whether or not the student has learned the simple basic relationships of physical chemistry. As such it should be valuable to teachers of physical chemistry as a source for examination question ideas or to students as a check to see whether or not they can deal adequately with the straightforward problems.

JAMES H. LOEHLIN
College of Wooster
Wooster, Ohio

Physicochemical Hydrodynamics

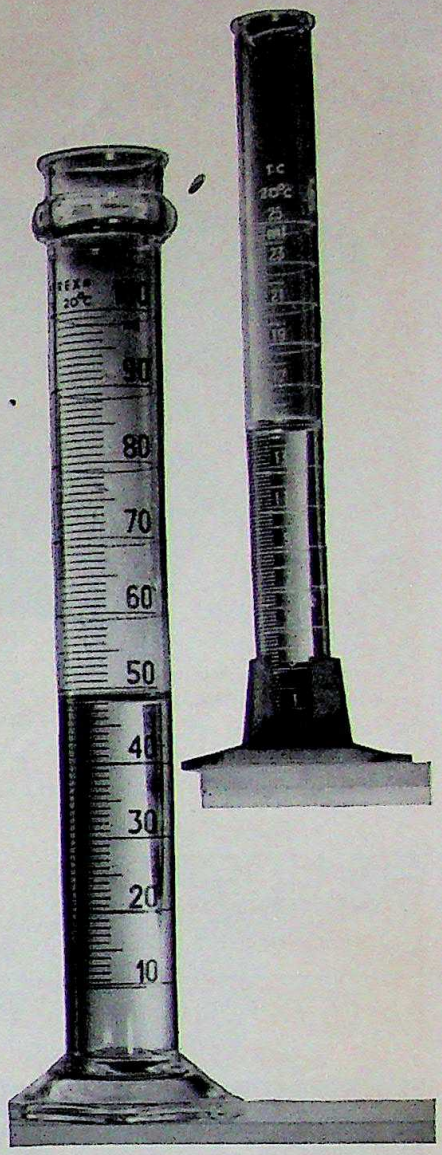
Veniamin G. Levich, Academy of Sciences, USSR. Translated by Scripta Technica, Inc. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962. xvi + 700 pp. Figs. and tables. 16 × 23.5 cm. $15.

This is the translation into English of the second edition of a book which was first published in the U.S.S.R. in 1952. The translation was prepared by Scripta Technica, Inc. and edited by L. E. Scriven assisted by A. Acrivos, J. Newman, T. J. Hanratty, S. Bruckenstein, and W. E. Ranz. It should prove to be a veritable gold mine of information for chemists and chemical engineers who deal with small scale hydrodynamics including especially the motion of drops, bubbles, and particles in fluid media, wave motion on a liquid surface, and motion in thin films. Although the title of the book stresses hydrodynamics, the other transport phenomena are not neglected. For instance, there are sections on convective diffusion to the surface of a rotating disk, diffusion in the concentration range near a critical solution point, the passage of current through an electrolytic solution, and the effect o surface active agents on the motion of bubbles, drops and waves. Many of these topics are just beginning to attract attention in the United States, and it is quite surprising to find that Professor Levich and his colleagues have been working intensively on such problems for a period of 20 years during which the theory has been developed to the point where an authoritative monograph could be prepared.

The material has been presented in an easily understood manner. Although the development of each topic eventually results in a mathematical analysis, the actual calculations are usually accompanied by a good narrative discussion in which the salient points are clearly presented. Within a given broad area, the author frequently discusses a series of related problems of increasing complexity and physical reality. The methods of higher mathematics are used whenever they are required. However, one never gets the feeling that the author is solving a mathematical exercise as an end in itself. In many cases, appropriate approximations are used in order to reduce the complexity of the analysis. As one would expect, this means that most of the discussions of such phenomena as diffusion to drops and particles are framed within the context of boundary layer theory.

There may be a few advanced under-

(*Continued on page A829*)



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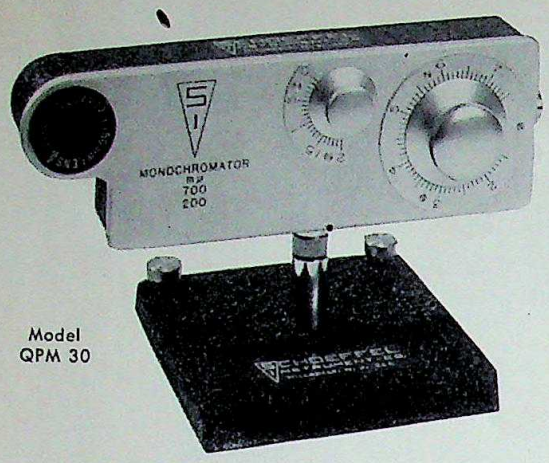

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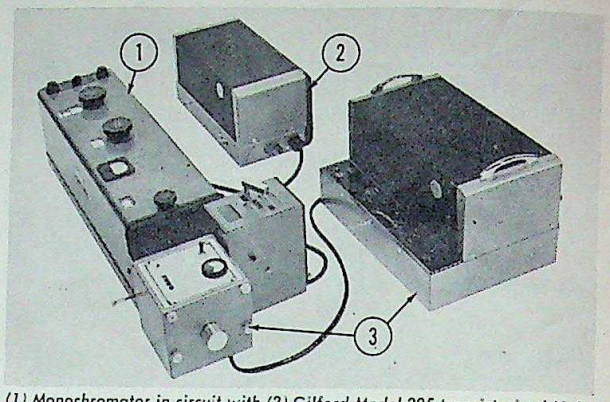

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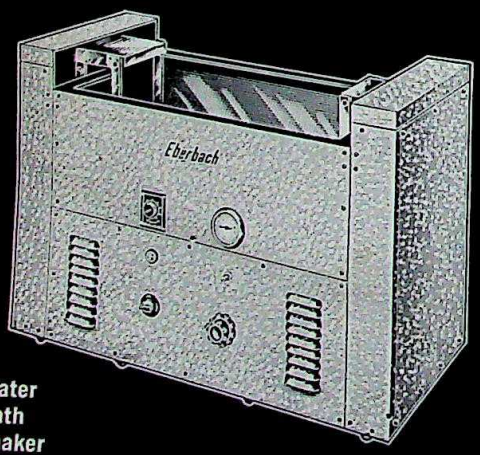

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graduate students who have progressed to the point where they can profitably study from this book, but it is probably best described as a graduate level text. Since only five and one-half pages are devoted to the continuity equation, the Navier-Stokes equations, and hydrodynamic boundary conditions, study from a book such as "Transport Phenomena" by Bird, Stewart, and Lightfoot would appear to be a prerequisite to effective use of "Physicochemical Hydrodynamics." Roughly the same amount of space is devoted to stating the equations of convective diffusion. Although the book is not suitable as a first text in transport phenomena, at least not without extensive supplementation, there is little doubt that many of the topics discussed in it will find their way into advanced courses.

The book is not a particularly handsome volume. The equations were apparently reproduced from the original Russian edition and, as a result, the symbols used in the text are somewhat different than those used in the equations. Furthermore, too many of the letters are improperly formed; for instance, there are eleven flaws on page five. On first reading, eleven obvious typographical errors were detected in the first sixty pages, but other sections were better.

In summary, "Physicochemical Hydrodynamics" is undoubtedly an important book which will influence thinking and research for many years to come. We are fortunate that it has been translated into English.

EUGENE H. WISSLER
University of Texas
Austin

Nouveau Traité de Chemie Minérale. Volume 9, Titane, Zirconium, Hafnium, and Thorium

Paul Pascal, general editor. Masson et Cie., Paris, 1963. xxxix + 1211 pp. Figs. and tables. 17.5 × 26 cm. 200NF, broché; 212NF, cartonné toile.

Volume 9 and the eighth volume of Pascal's new treatise on inorganic chemistry are organized to cover the materials concerning elements of Group IV. This volume is devoted to titanium, zirconium, hafnium, and thorium. Chrétian and Freundlich are authors of the section on titanium, Albert, Langeron, and Lehr of that on zirconium and hafnium, and Flahaut is sole author of the section on thorium. About half of the volume is reserved for the material on zirconium and hafnium, and the remainder is about equally divided between titanium and thorium. Much emphasis is placed upon processes for the extraction and purification of the four elements, particularly for those involving zirconium and hafnium.

Much attention has been given to the bibliographies, and there are some 6600

(*Continued on page A830*)

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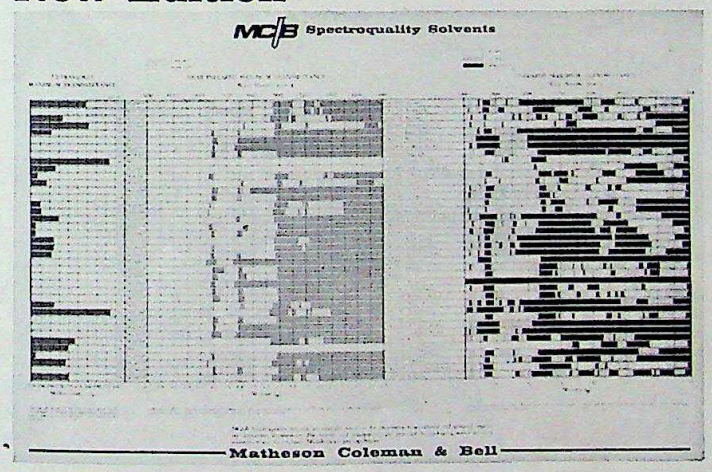

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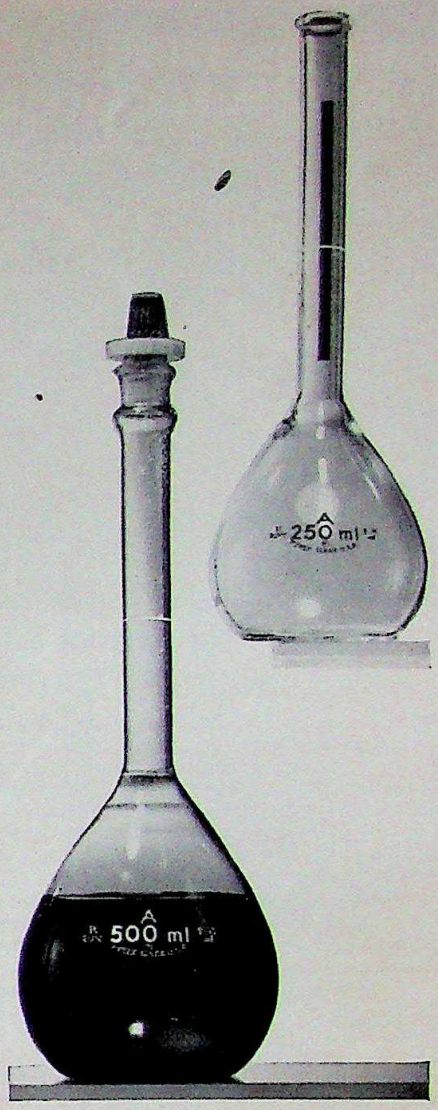

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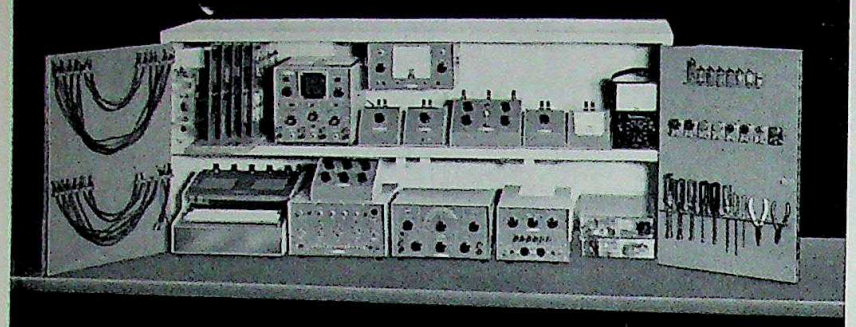

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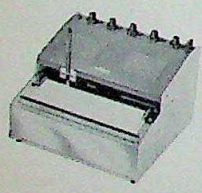

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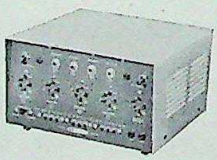

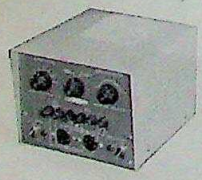

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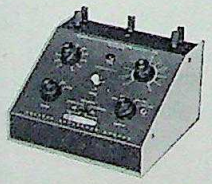

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references included in the work. Yet despite a publication date of 1963, with some exception, most of the searching of the literature appears to have been done prior to 1961. Bibliographies for titanium and thorium do not go beyond 1960, and appear to have been prepared primarily in 1958.

Illustrations are employed frequently throughout the volume, as well as numerous tables. Ten pages of indexes are included, but in general the indexes are not especially thorough, although metal systems are well indexed. This is helpful in locating various phase diagrams. The organization of the material on the elements and their compounds is well done, and this makes the volume an excellent reference source. Generally high standards have been maintained throughout publication of the treatise to date, and this volume indicates that they are being maintained.

ROGER V. KRUMM
University of Florida
Gainesville

The Chemistry of the Lanthanides

Therald Moeller, University of Illinois, Urbana. Reinhold Publishing Corp., New York, 1963. ix + 117 pp. Figs. and tables. 12.5 × 19 cm. Paperbound. $1.95.

The editors of the paperback series, Selected Topics in Modern Chemistry, have recognized in the lanthanides an excellent topic for one of their little books intended as supplements to any standard text in first-year chemistry and made a wise choice in selecting Professor Moeller to write the book, since he is a lucid writer and an expert on this topic.

The book is very well planned. The first two chapters cover the subject quite adequately for the reader who is seeking only general information. The third and fourth chapters discuss chemical and technological matters in some detail, and the final chapter briefly presents the actinides as another series of closely related elements whose chemistry has rendered that of the lanthanides no longer completely unique.

Professor Moeller approaches his subject with a historical account that begins with the discovery of an unusual black mineral specimen at a quarry at Ytterby by Swedish Army Lieutenant C. A. Arrhenius in 1787. The unraveling of the complexity of the "earths" named *yttria* and *ceria* is an object lesson in the rewards of infinite patience. The historical account is concluded with a section on the elusive element 61, which was finally identified in materials obtained at Oak Ridge from the fission of uranium by Marinsky, Glendenin, and Coryell in 1947.

In the second chapter the essential uniqueness of the chemistry of the lanthanides is related to the uniqueness of their atomic structure. Here the reader

(*Continued on page A832*)

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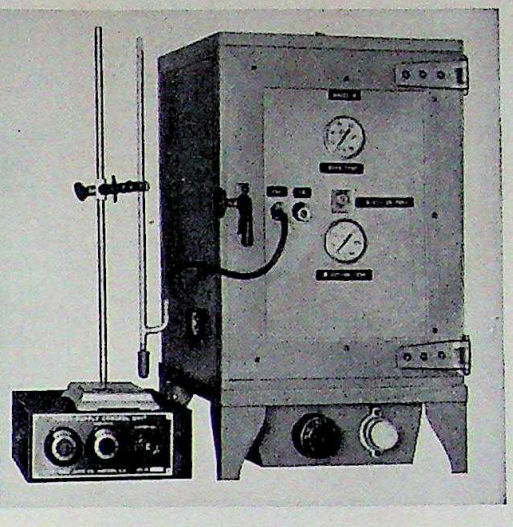

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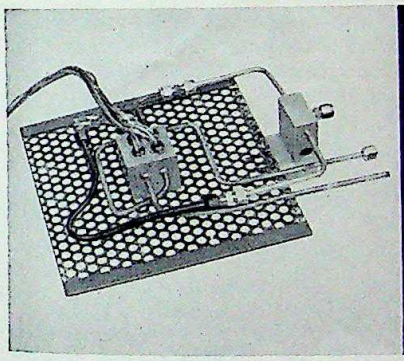

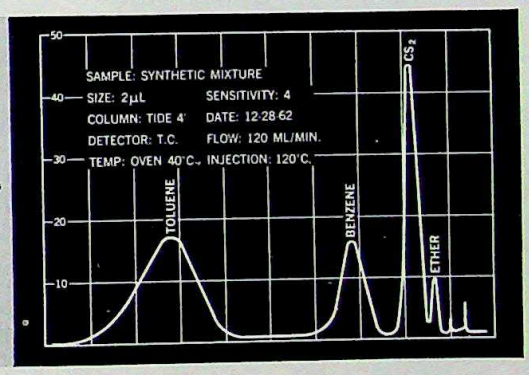

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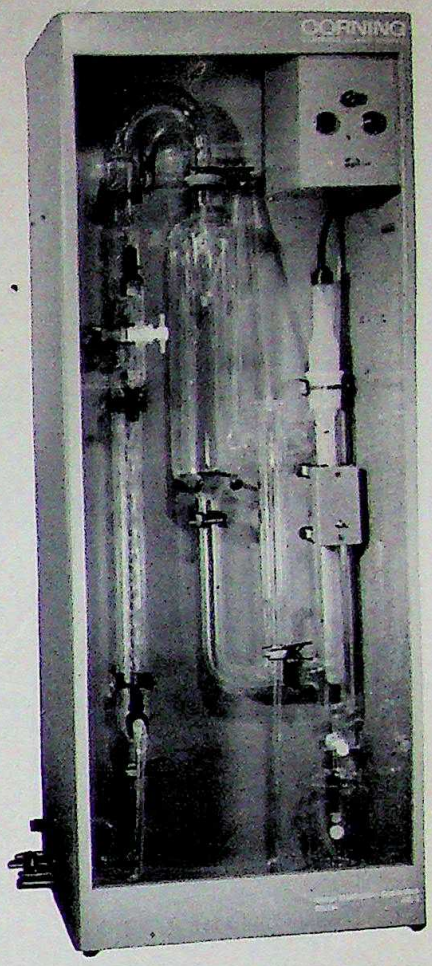

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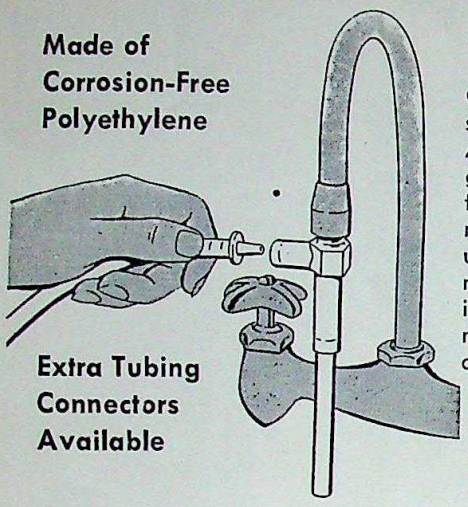

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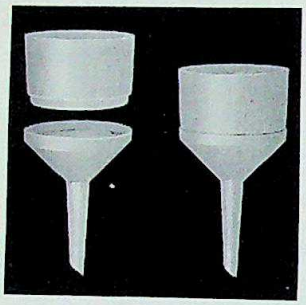

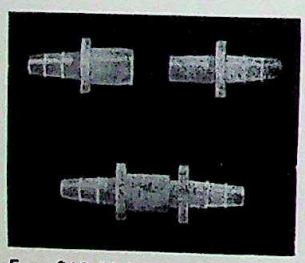

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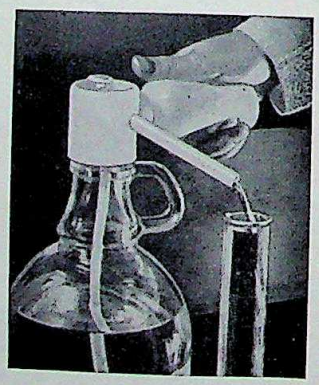

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learns to identify the lanthanides as the 4*f* elements. Nevertheless, yttrium and lanthanum because of their chemical properties are better discussed with the lanthanides than with any other elements. Scandium is markedly different; even though it was first isolated from yttria, its primary mode of occurrence is not with the lanthanides.

Moeller accounts for the oxidation states of the lanthanides in terms of electronic configuration, insofar as this is possible. The reader is candidly told, and shown, that direct correlation between the two is the exception rather than the rule. The powerful reducing action of the elemental lanthanides is correlated with their large atomic size, as are the pronounced ionic character of lanthanide compounds and the paucity of complex species. Consequences of the lanthanide contraction are discussed, such as the invariable natural occurrence of yttrium with the heavier lanthanides and the small variations in properties that permit separation of the lanthanides by fractional operations.

The third chapter supplements the chemical information already presented by discussing in some detail the general chemistry of the lanthanides in terms of their several oxidation states. This presentation provides the background essential to underatanding the problems of recovery and separation treated in the fourth chapter.

The fifth chapter provides a brief consideration of the actinides. The theme of this final chapter is Seaborg's hypothesis that the elements following actinium constitute a second inner transition series, i.e. that they are 5*f* elements.

The value of this excellent little book, the seventh in the series, is enhanced by a complete index and by a valuable list of selected readings at the end of each chapter.

LAWRENCE P. EBLIN
Ohio University
Athens

Nouveau Traité de Chemié Minérale. Volume 8, Germanium, Étain, Plomb

Paul Pascal, general editor. Masson et Cie., Paris, 1963. xxxix + 816 pp. Figs. and tables. 17.5 × 26 cm. 136NF, broché; 148NF, cartonné toile.

Volume 8 of the new treatise by Pascal on inorganic chemistry is to appear in three parts, and it will include the material on the elements carbon, silicon, germanium tin, and lead. Part Three is the only part published to date, and it includes the elements germanium, tin, and lead. With volume 9, this volume, will cover the elements in Group IV.

The section on germanium was written jointly by A. Tchakirian, P. Bevillard, and A. Godfrin. The section on tin was written by B. Lemanceau, except for the material concerning organic compounds of tin, which was written by Pascal himself, and the section on lead was written by R.

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Faivre and R. Weiss. Separate paging for each of the three projected parts evidently is intended, as this part has its own paging and indexing, although it is designated as the third part of volume. The tables in the section for tin are used frequently and effectively, and they have excellent bibliographic notes.

As is the case with the entire treatise, bibliographies are listed frequently and contain numerous references. A number of bibliographies might well have been brought closer to the date of publication, and a few do not go beyond 1953, although most are reasonably up to date. The index is far from thorough but a good arrangement in the treatment of each element and its compounds does much to overcome this handicap.

The greatest use of the set undoubtedly will be as a reference tool, but much use can be made of individual volumes and their parts for intensive reading and study as well. This appears to be the case with the material in this part of Volume 8.

ROGER V. KRUMM
University of Florida
Gainesville

Outlines of Biochemistry

Eric E. Conn and *P. K. Stumpf*, both of the University of California, Davis. John Wiley and Sons, Inc., New York, 1963. viii + 391 pp. Figs. and tables. 15.5 × 23.5 cm. $8.75.

An introductory course, and a textbook designed for an introductory course, should prepare the student to proceed to advanced courses and to read, with good comprehension, advanced treatises, monographs, reviews, and the original literature of the subject. Professors Conn and Stumpf have succeeded admirably in their endeavor to prepare a textbook for a one-semester course in biochemistry for upper-division undergraduates and beginning graduate students.

From this book the student can acquire the essential vocabulary and the outlook of modern biochemistry. He will review briefly but clearly certain aspects of organic, analytical, and physical chemistry, that are fundamental to and illuminate areas in biochemistry. Appendix 2 reviews some modern concepts in organic chemistry by definition and example. Appendix 3, Methods in Biochemistry, describes concisely, but not as a laboratory guide, a number of techniques of biochemical research. Chapter 1 reviews *p*H, and other calculations applied to solutions of electrolytes. Appendix 1 reviews logarithms and offers a number of buffer problems. Biochemical Energetics is outlined with reference to free-energy and its determination, oxidation and reduction potentials, and the types of biochemical energy-rich compounds with discussion of the causes of their high negative free-energies of hydrolysis. The chemical nature and structures of the carbohydrates, lipids, proteins and amino acids, and the nucleic acids and their components are [illegible]

The remaining two thirds of the book is devoted to the exposition of the metabolism of biochemical compounds and the integration of metabolism, presented clearly with pertinent diagrams, figures, equations, and schemes for reaction sequences. After the general characterization of the enzymes in one chapter, the individual enzymes, of known metabolic importance, are introduced as the reactions they catalyze are encountered. Vitamins are presented as participants in metabolism with emphasis on the coenzymatic activities of their derivatives and with indication of what is known of those vitamins (K, E, A, D, and C) with no established coenzymatic function. Nutritional aspects of the vitamins are not included.

The authors have concisely presented the salient aspects of the catabolism of the carbohydrates and fats, and the associated and ensuing electron transport and oxidative phosphorylation. The catabolism of the amino acids is briefly indicated. Outlines of the biosynthesis of carbohydrates (including photosynthesis), fatty acids, other lipids, purines, pyrimidines, porphyrins, nucleic acids, and proteins are admirably up-to-date. Digestion, absorption and excretion: the urea cycle, and the nitrogen cycle in nature are outlined. Clear introductions to biochemical genetics and metabolic regulation are especially comment-worthy.

This book, not designed to be exhaustively encyclopedic, provides, in brief compass but in generous measure, a reference "dictionary" for terms, concepts, and reactions of modern biochemistry. As

(*Continued on page A834*)

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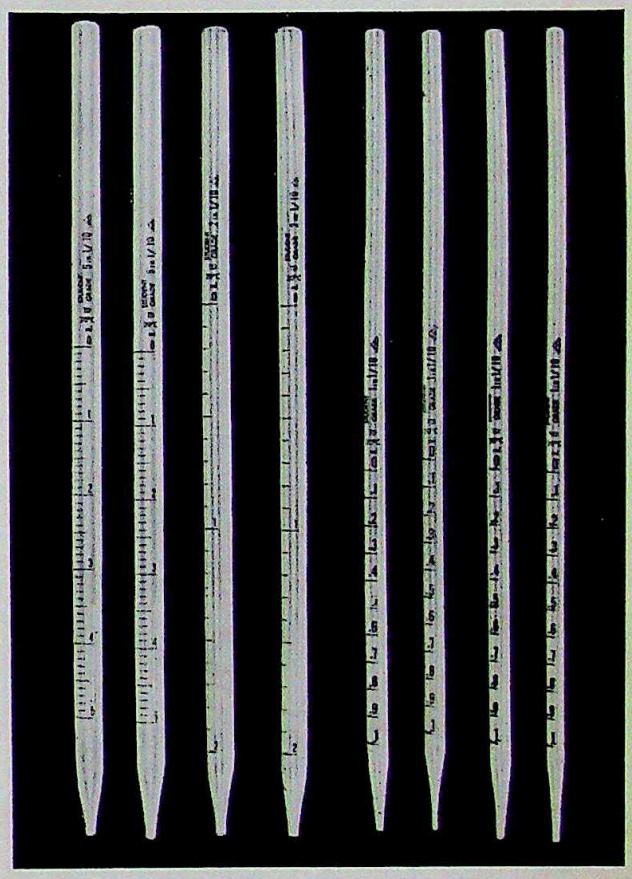

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such it well merits library space. It is well indexed. The authors are to be congratulated for the success they have achieved in writing this well integrated textbook. They have included certain references and the value of the very brief lists is increased by the concise descriptive comment about each book and review article. Supplementary reading should be stimulated. This shorter textbook is highly recommended.

RALPH C. CORLEY
Purdue University
Lafayette, Indiana

Practical Clinical Biochemistry

Harold Varley, Manchester University, England. 3rd ed. William Heinemann Medical Books, Ltd., London, and Interscience Books, Inc. (a division of John Wiley and Sons, Inc.), New York, 1962. viii + 689 pp. Figs. and tables. 14.5 × 22 cm. $0000

According to a statement on the inside cover, the object of this book is to give a comprehensive account of the many biochemical tests now carried out in hospital laboratories as an aid to the diagnosis and treatment of disease. In each chapter there is given at first an outline of various basic principles which lend themselves to the development of testing methods for a particular blood or urine constituent. This is followed by a few selected techniques which are described in detail so that they can be performed without consulting the original articles. Next comes a section in which the significance of the test is discussed and interpretations of the diagnostic implications of a particular result are given in a clear and concise manner. At the end of each chapter there is a list of references which this reviewer finds very useful.

The book consists of 29 chapters, starting with an introductory description of the collection and handling of specimen, notes on colorimetry, and a discussion of control of accuracy, and followed by 28 chapters devoted to various blood and urine constituents.

For those who own previous editions of this book it might be of interest to know that this new third edition contains now a chapter on enzymes (transaminases, lactic dehydrogenase, aldolase, cholinesterase). The chapter on acid-base regulation has been rewritten to include the Astrup techniques. Among other additional newer methods are the glucose oxidase technique for blood glucose, the determination of methylated amines and of hydroxy-methoxy-mandelic acid (in the section dealing with adrenaline and noradrenaline), the d-xylose excretion test, enzyme methods for blood pyruvate and lactate, a technique for the determination of pregnanetriol, and the diacetyl monoxime method for urea.

The author is quite familiar with the recent American literature in clinical chemistry and many of the methods selected have originated here. Nevertheless, there is a distinct British flavor to the book. Some of the apparatus illustrated are hardly, if ever, encountered in the USA and demonstrate nicely that we do not have a monopoly on the manufacturing of precision equipment. A table of normal body weights might puzzle the American reader unless he knows that 1 stone equals 14 pounds or 6.350 kilogram. In contrast to American usage, blood urea is expressed as such (milligram urea per 100 ml. of blood) and not as B.U.N. (milligram blood urea nitrogen per 100 ml.).

Most of the analytical procedures described are similar to or identical with those used in hospital laboratories in the USA. Sometimes, however, one encounters techniques which are unnecessarily cumbersome or outdated. The simple method of Mindlin and Butler for the determination of ascorbic acid in plasma, for example, is mentioned but not described, whereas a more complex procedure is given in detail. The determination of total protein by the copper sulfate specific gravity method is hardly of more than historical interest. In his discussion of non-protein nitrogen determinations the author mentions that trichloracetic acid (instead of tungstic acid) may be used for the preparation of protein-free filtrates. It might be well to add that trichloracetic acid is preferable since it decomposes during digestion into volatile CO_2 and $CHCl_3$, whereas tungstic acid remains and

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is apt to cause turbidity during subsequent nesslerization.

In summary: this is not just another "cook-book-style" collection of procedures, but an intelligently written well balanced book with a wealth of useful information. It should be in the library of clinical chemists and of those interested in analytical aspects of biochemistry.

OTTO SCHALES
Tulane University School of Medicine
New Orleans, Louisiana

New Volumes in Continuing Series

The following titles are those of volumes in continuing series. Many of these series are familiar to readers, who are best served by prompt announcement of the appearance of new titles. The policy of THIS JOURNAL will be to publish full reviews only of inaugural volumes in new series. The publication of later volumes will be announced in this column. Full bibliographic information will be supplied as well as a list of contributing authors.

Modern Materials: Advances in Development and Applications. Volume 3

Edited by *H. H. Hausner*, Polytechnic Institute of Brooklyn, Brooklyn, New York. Academic Press, Inc., New York, 1962. xv + 475 pp. Figs. and tables. 16 × 23.5 cm. $15.

Contributors: Frank M. Precopio, Merrill Cohen, and Algerd F. Zavist; F. S. Rollins; J. M. Haspers; S. Triebwasser; C. B. Jackson and J. W. Mausteller.

Advances in Clinical Chemistry. Volume 5

Edited by *Harry Sobotka*, Mount Sinai Hospital, New York, and *C. P. Stewart*, University of Edinburgh, Scotland. Academic Press, Inc., New York, 1962. xiv + 328 pp. Figs. and tables. 16 × 23.5 cm. $12.

Contributors: L. I. Woolf; A. C. Frazer; B. Skarżyński and M. Sarnecka-Keller; C.-B. Laurell and C. Grönvall; Herman Baker and Harry Sobotka; F. H. Bruns and P. H. Werners.

Methods of Biochemical Analysis. Volume 11

Edited by *David Glick*, Stanford University Medical School, Palo Alto, California. Interscience Publishers (a division of John Wiley and Sons, Inc.), New York, 1963. ix + 442 pp. Figs. and tables. 16 × 23.5 cm. $14.50.

Contributors: J. B. Willis; E. C. Horning, W. J. A. VandenHeuvel, and B. G. Creech; I. E. Bush; Morton K. Schwartz and Oscar Bodansky; Irwin J. Kopin; F. L. Crane and R. A. Dilley; Robert P. Davis; Otto H. Müller.

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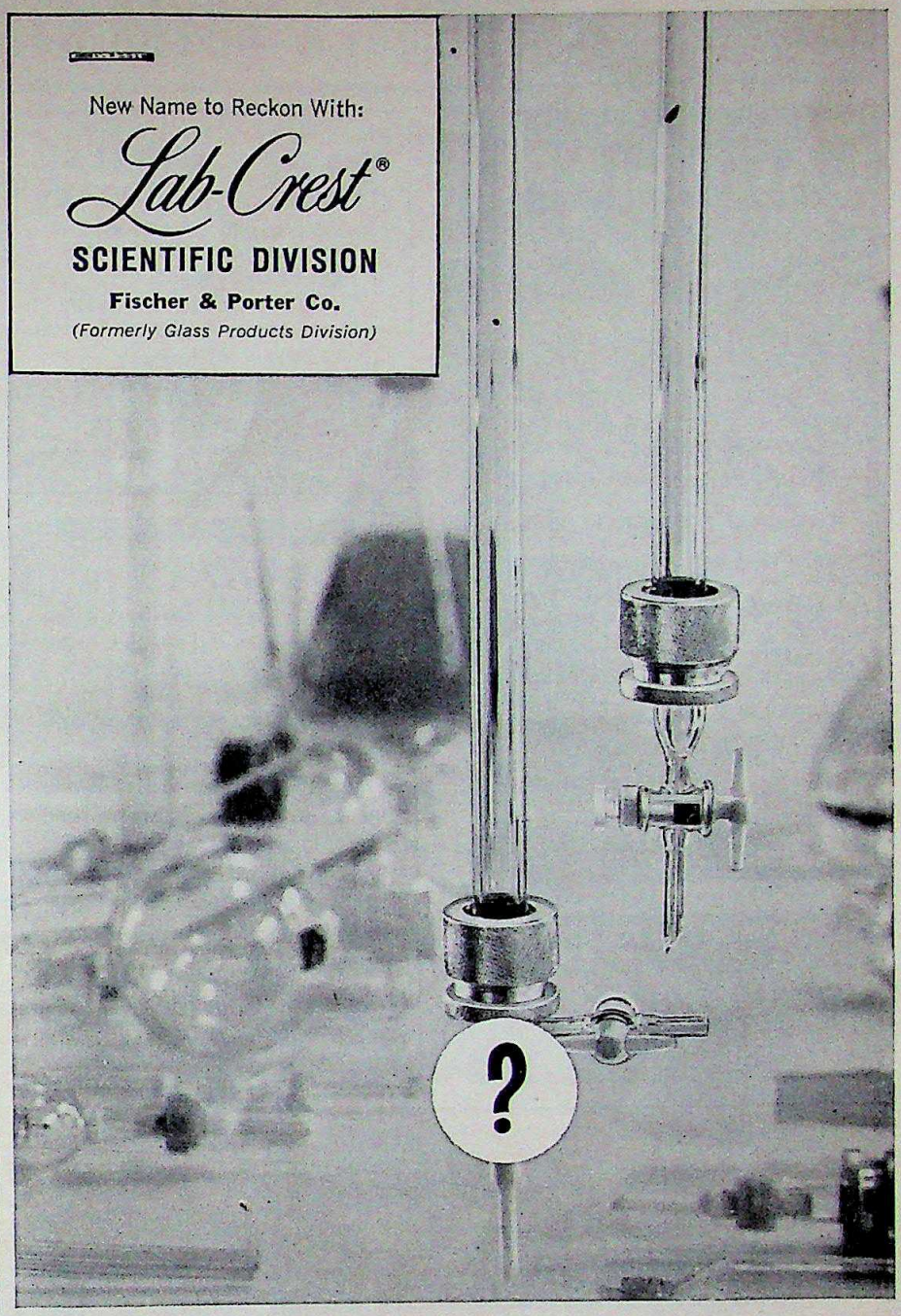

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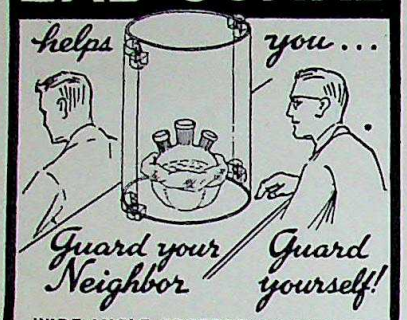

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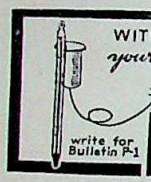

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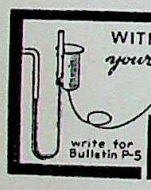

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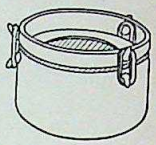

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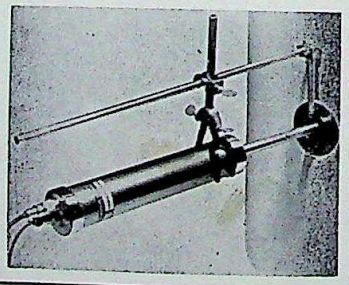

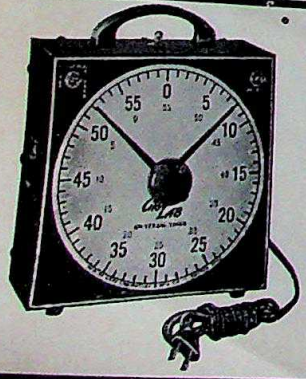

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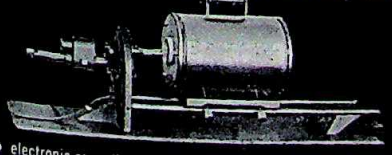

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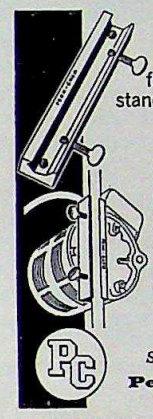

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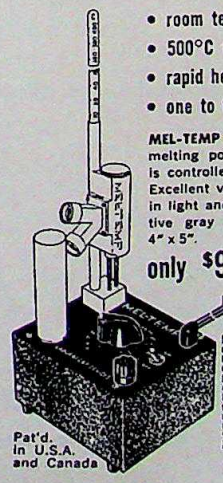

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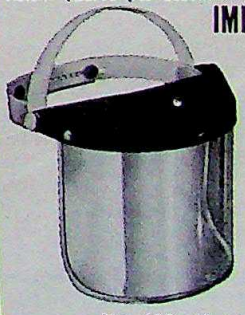

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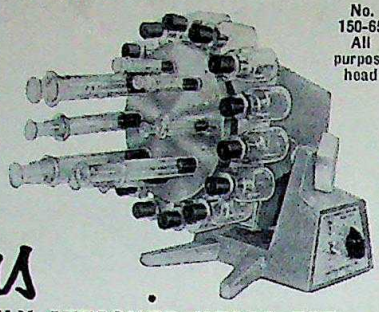

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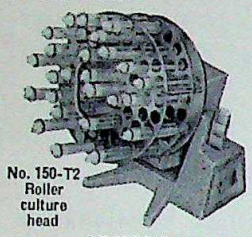

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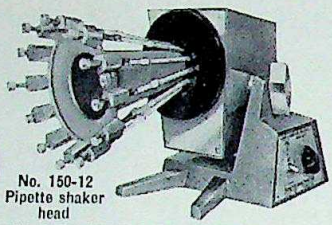

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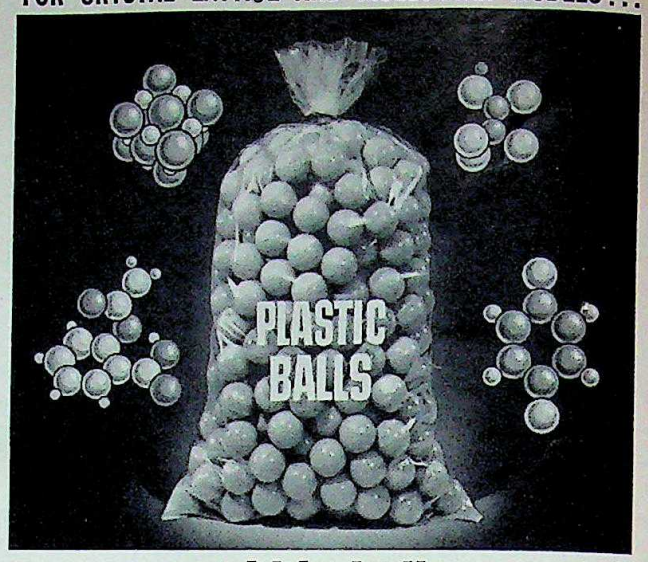

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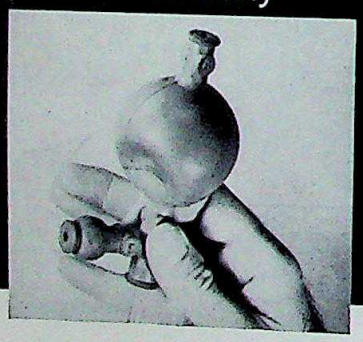

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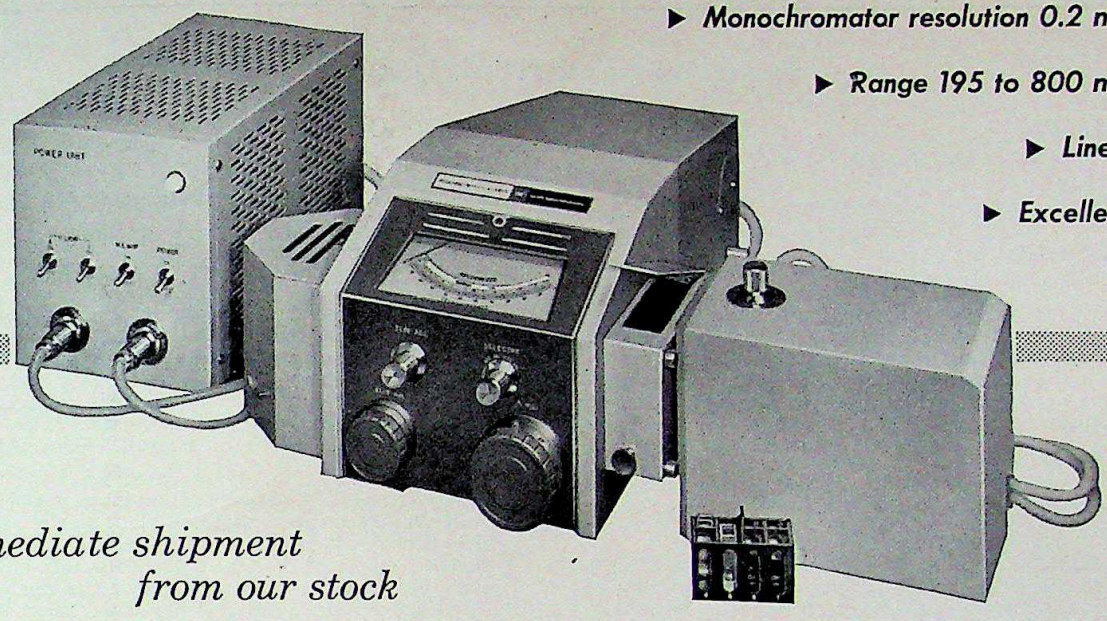

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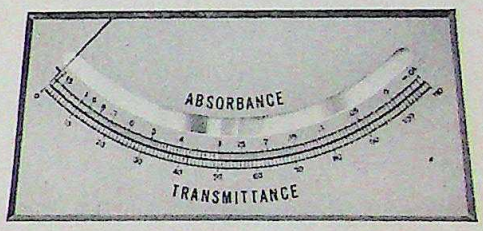

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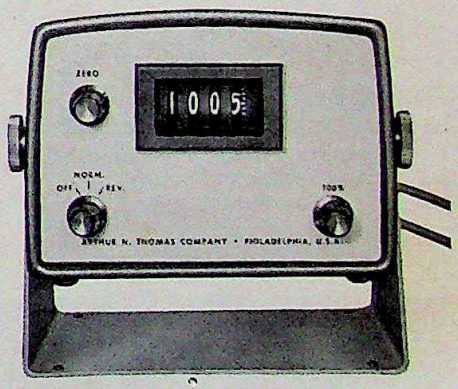

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These articles, most of which are to be contributed by guest authors, are intended to serve the readers of this JOURNAL *by calling attention to new developments in the theory, design, or availability of chemical laboratory instrumentation, or by presenting useful insights and explanations of topics that are of practical importance to those who use, or teach the use of, modern instrumentation and instrumental techniques.*

XII. Pressure Measurement. Part Three

Seymour T. Zenchelsky, *School of Chemistry, Rutgers, The State University, New Brunswick, New Jersey*

The preceding parts of this article dealt with liquid-column, mechanical, and thermal gauges. This part concludes the article.

Ionization Gauges

Several different kinds of ionization gauges are available, and, in combination, they cover the range of pressures from atmospheric down to 10^{-13} mm Hg. Thus these gauges extend the range of measurement to pressures far below those within the capability of the devices already described. In fact, ionization gauges are indispensable for the measurement of pressures below 10^{-7} mm Hg.

Principle of Operation. All ionization gauges depend upon the measurement of an electric current which results from the ionization of a gas whose pressure is being determined, but the various types differ principally in the method of ion production. For, in order to convert a gas molecule into a positive ion, it is necessary to remove an electron by supplying energy equal to the *ionization potential* of the molecule involved. And this energy—between 4 and 25 electron-volts—may be introduced in a variety of ways, some of which will be described below.

When the requisite energy is supplied at a constant rate, the rate of ion production is also constant, and almost exactly proportional to the pressure of the gas. Thus when the ions and electrons are collected under the influence of a constant potential gradient, the observed current is proportional to the rate of production, and hence to the gas pressure. Ion currents are measured by means of conventional electrometer circuits.

Ion Production. Two methods are commonly used for introducing the energy necessary to ionize the gas: electron bombardment or bombardment by nuclear radiation.

Ionization gauges which utilize the first method fall into two classes: *hot-filament* gauges and *cold-cathode* gauges. The former derive their designation from the fact that electrons are furnished by thermionic emission (as in the ordinary radio tube), while the latter depend upon a high potential-field for the withdrawal of electrons from the (cold) cathode. Since the electron-emission rate is smaller for the cold-cathode type, it is necessary to increase the frequency of collisions between the electrons and gas molecules. This is accomplished by surrounding the gauge with a magnetic field in order to deflect the electrons. Their resultant path is thus cycloidal, rather than linear, thereby increasing their transit time (and hence their probability of collision with gas molecules). Cold-cathode gauges are also designated Philips gauges or Penning gauges.

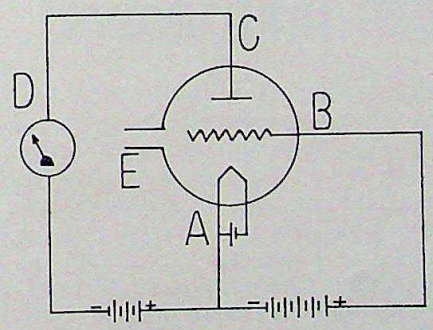

Figure 37. Simple hot-filament gage.
A—filament
B—anode
C—ion collector
D—ion-current meter
E—system connection

Those gauges which employ radioactive sources to produce ionization are less frequently used than the others because they cover only the range of pressures from 10^{-3} mm Hg to atmospheric. They contain either tritium compounds (beta particles) or radium salts (alpha particles) as the source of ionizing radiation. In both cases the energies of the particles are far in excess of the requisite ionization energy.

Hot-Filament Gauges. The simplest kind of hot-filament gauge is an ordinary triode as shown in Figure 37. Variations in design are chiefly directed toward the following objectives: (1) prolonging element life, (2) minimizing the inconvenience of filament burnout, and (3) extending the lower pressure-limit. Pursuit of the first two objectives has resulted in the use of filaments made of various materials, or of double filaments to permit rapid change-over without removal of the gauge tube. The third objective has led to changes in electrode design and spacing.

Figure 38. Elion Vacuum Gage Control, Model DVG-5. This gage covers the range 10^{-3} mm Hg to 2×10^{-10} mm Hg in six decades. It contains outgassing and filament-protection circuits. Recorder output is available at the rear of the cabinet. Other models are available.

The lower pressure-limit is governed by the magnitude of the observed *residual* current, which is completely independent of the gas pressure. This current results from the ejection of photoelectrons, from the ion-collector electrode, by X-rays which are produced when electrons strike the anode. By means of changes in the physical shape and placement of the electrodes, the number of X-ray photons reaching the collector electrode can be decreased. Thus Bayard, Alpert, and Nottingham were able to decrease the lower pressure-limit from 10^{-8} mm Hg to 10^{-11} mm Hg. Lafferty further lowered this limit to approximately 10^{-13} mm Hg by adding an external magnetic field in order to increase the number of collisions between electrons and gas molecules.

All components of the hot-filament gauge must be thoroughly freed of adsorbed gases prior to use. This is accomplished by heating the tube invelope to 450°C and using either electron bombardment or resistive heating for the electrodes. A serious disadvantage of the hot-filament is its susceptibility to burn-

(*Continued on page A850*)

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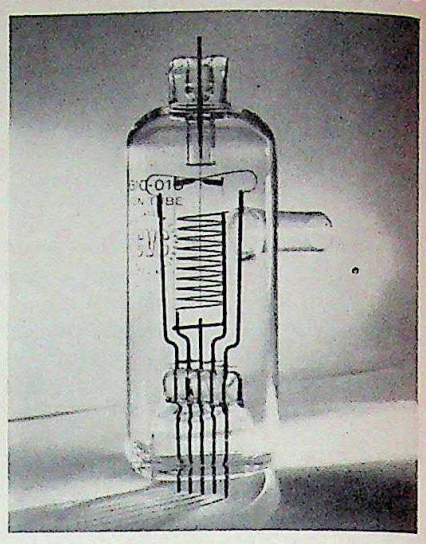

Figure 39. Consolidated Vacuum Corporation, GIC-016 Ionization Gage Tube. It utilizes the Bayard-Alpert construction and incorporates two filaments for rapid changeover in case of burnout.

out in the presence of even moderate pressures of air; thus many gauges provide for automatic cutoff of the filament voltage when the pressure rises above a preset level.

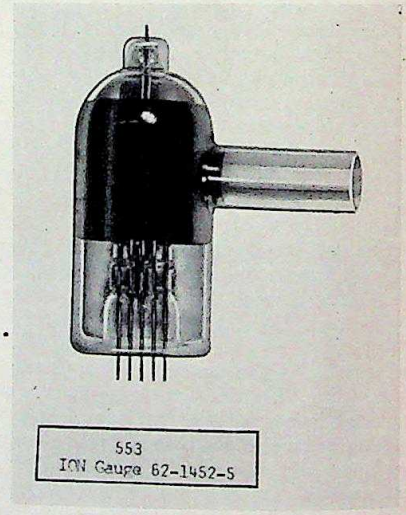

Figure 40. NRC Equipment Corporation, Model 533 Ion Gage Tube. This tube features a platinum coating inside the envelope for electrostatic shielding. It also has a dual filament.

Various hot-filament gauges are available from those companies already listed in Part Two, under *Thermal Gages*. Most of these incorporate a number of the design features mentioned above. They generally use the Bayard-Alpert type gauge tube and indicate pressure on a linear scale, with several decades provided by means of a switch. Most models, other than the least expensive, provide automatic filament-burnout protection as well as provisions for outgassing the electrodes and recorder connection. Typical ranges are 10^{-5} to 10^{-9}, or 10^{-3} to 10^{-10}, mm

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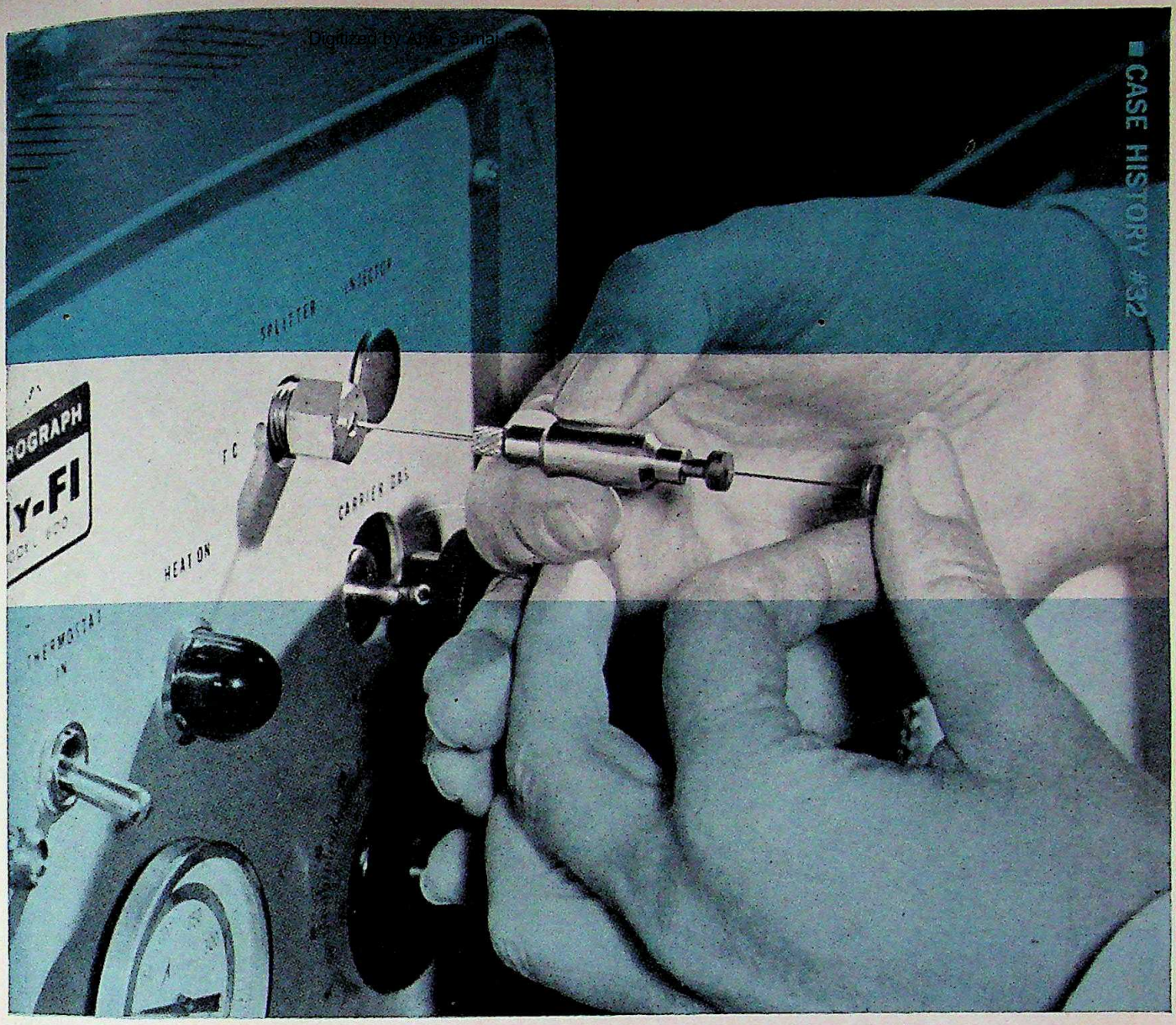

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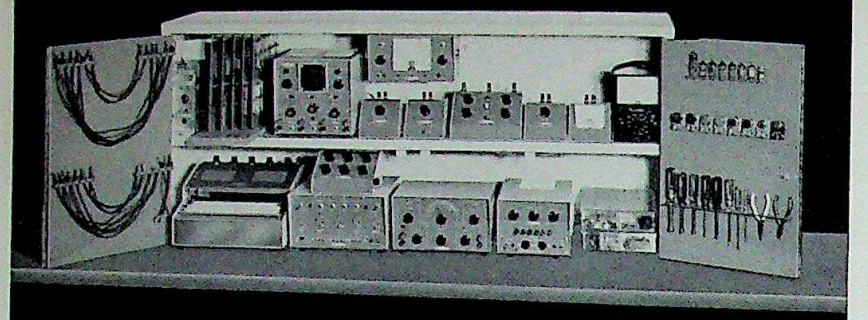

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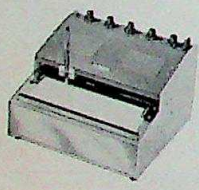

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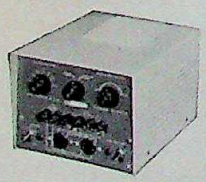

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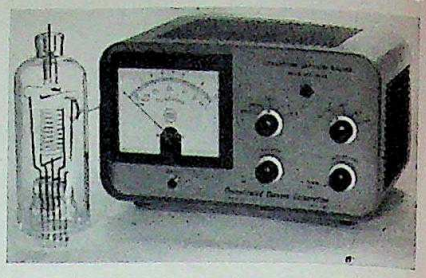

Figure 41. Consolidated Vacuum Corporation, Type GIC-110A Ionization Vacuum Gage. It covers the range 10^{-3} mm Hg to 10^{-9} mm Hg on a linear scale in five decades. In addition, the range from 2 mm Hg to 0^{-3} Hg is covered by a thermal gage. More elaborate models are also available.

Hg, usually covered in six decades. Some models also include a thermocouple gauge so as to extend the high pressure limit to one mm Hg. Only a few of the available models are shown in Figures 38, 39, 40, 41, and 42.

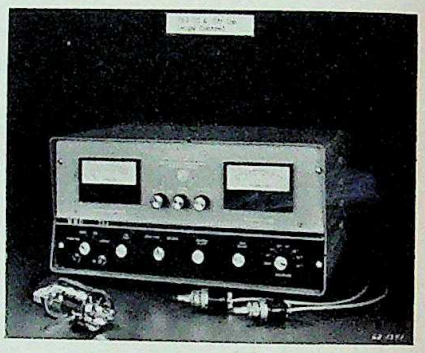

Figure 42. NRC Equipment Corporation, Model 763 Combination Ultra High Vacuum Gage Control. This gage covers the range from 10^{-3} mm Hg to 10^{-10} mm Hg in six linear decades. It also has an integral thermocouple gage to extend the range up to 2 mm Hg. This model possesses filament-protection and outgassing circuits as well as recorder terminals. Other models are available.

Cold-Cathode Gauges. These gauges (also called *discharge gauges*) are more rugged than the hot-filament types. The gauge tubes are generally made of metal and they can be cleaned or repaired easily. There are no filaments to burn out upon accidental exposure to high pressure. On the other hand, cold-cathode gauges are not easily degassed and are subject to contamination by breakdown-products from the gas.

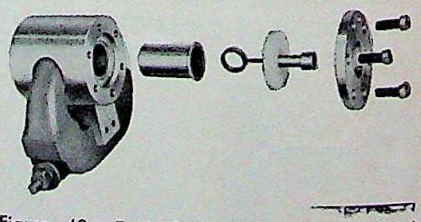

Figure 43. F. J. Stokes Corporation, Model DG-10 Cold Cathode Type Discharge Tube. A unique feature of this gage is the ease of replacement of the gage-tube elements and their ease of cleaning. The associated gage control permits coverage of the range from 10^{-1} mm Hg to 10^{-6} mm Hg.

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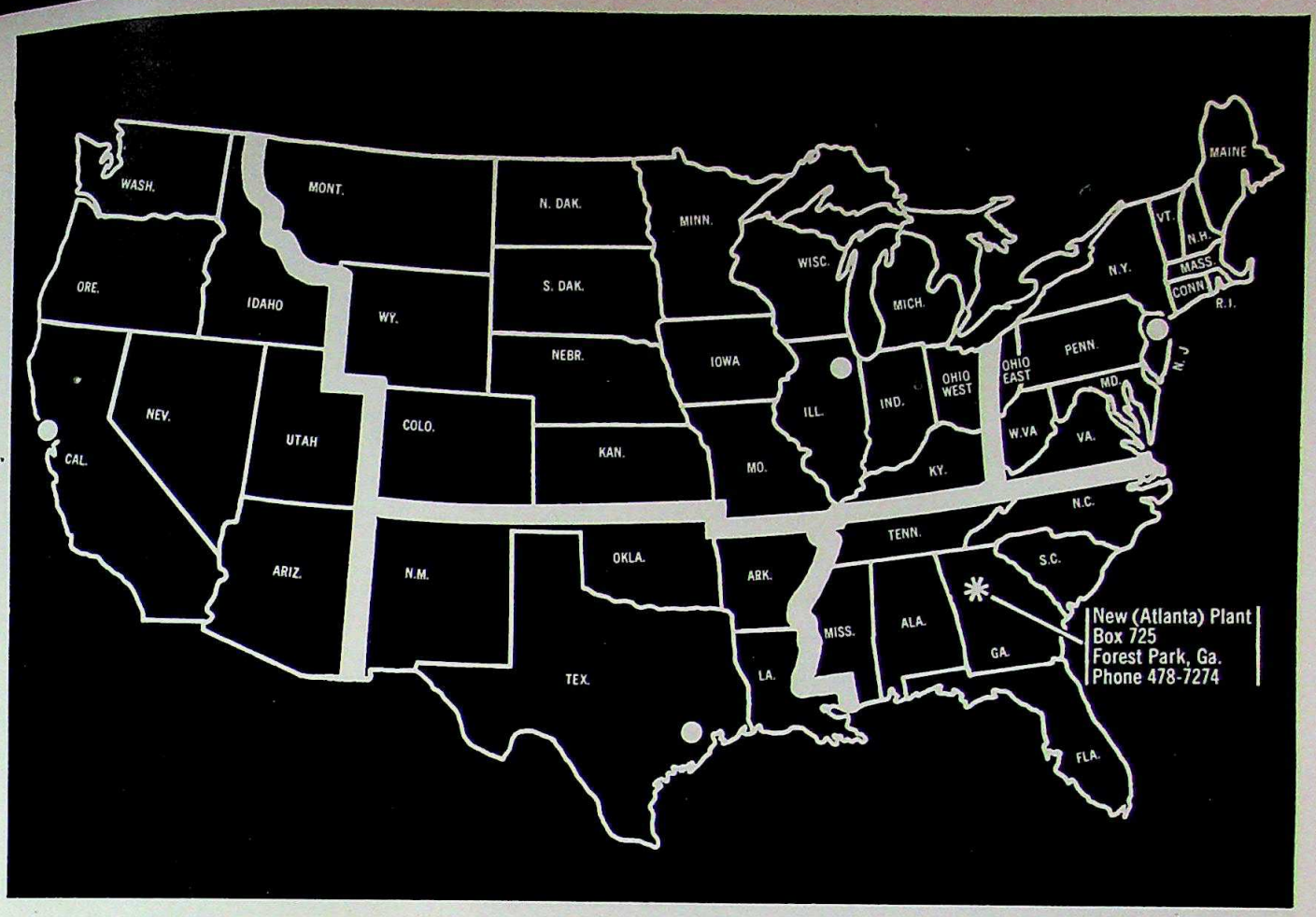

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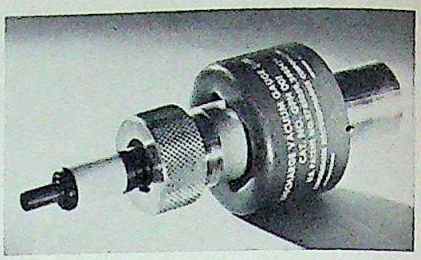

Figure 44. Consolidated Vacuum Corporation, GPH-001 Discharge Vacuum Gage Tube. The permanent-magnet collar is encased in plastic "to protect against loss in strength due to contact with surrounding steel objects."

limit was dropped to 10^{-12} mm Hg by Redhead, who redesigned the gauge tube and used crossed magnetic and electric fields externally in order to decrease the X-ray background.

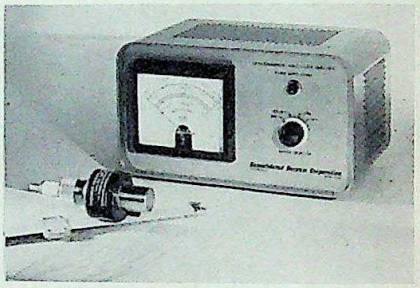

Figure 45. Consolidated Vacuum Corporation, Type GPH-100A Discharge Vacuum Gage. This control, used with the GPH-001 gage tube, provides a range from 2.5×10^{-2} mm Hg to 10^{-7} mm Hg on three nonlinear scales. More elaborate models are available.

Many models are available commercially. Some are equipped for multi-station operation as well as for recording and control. Some of these are shown in Figures 43, 44, 45, and 46.

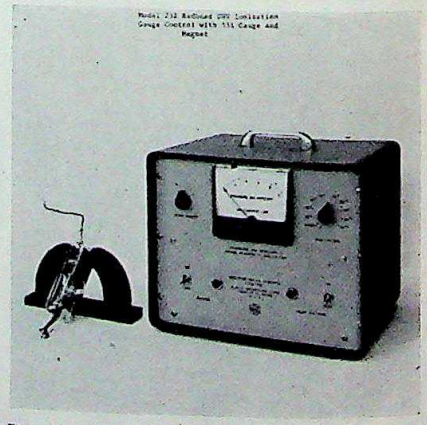

Figure 46. NRC Equipment Corporation, Model 752 Redhead UHV Ionization Gage Control with 551 Gage and Magnet. An extremely sensitive gage, using crossed electric and magnetic fields, This model provides a range from 10^{-4} to 10^{-13} mm Hg on a linear scale of nine decades. Recorder terminals are provided and no outgassing of the electrodes is required.

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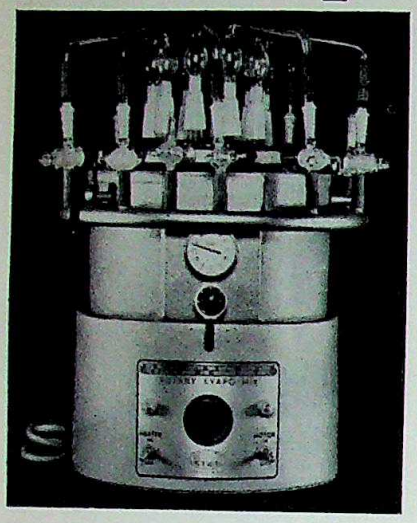

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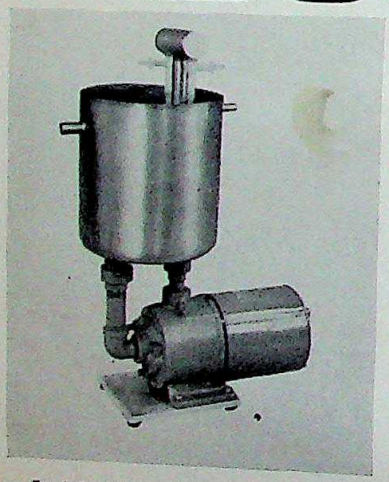

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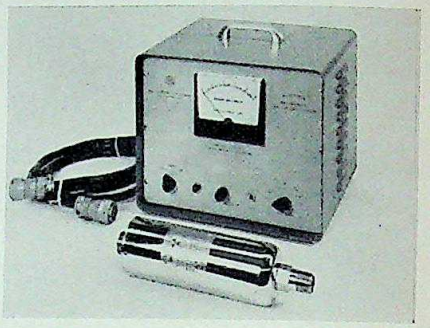

Figure 47. NRC Equipment Corporation, Model 530 Alphatron Vacuum Gage. This gage covers the range from atmospheric pressure down to 10^{-4} mm Hg in seven linear scales.

All of the above gauges are calibrated to read directly for dry air, but—as with the thermal gauges—they require a correction for other gases.

Bibliography

(1) Dushman, S., and Lafferty, J. M., Editors, "Scientific Foundations of Vacuum Technique," Second Ed., John Wiley and Sons, Inc., 1962, New York. Chapter 5.

(2) Reilly, J., and Rae, W. N., "Physico-Chemical Methods," Vol. I, Fifth Ed., D. Van Nostrand Co., Inc., 1953, New York. Chapter VI.

(3) Lion, K. S., "Instrumentation in Scientific Research," McGraw-Hill Book Co., Inc., 1959, New York, pp. 101–117.

(4) Consolidated Vacuum Corporation, "High Vacuum Gauges," Bulletin 9-1, Rochester, N. Y.

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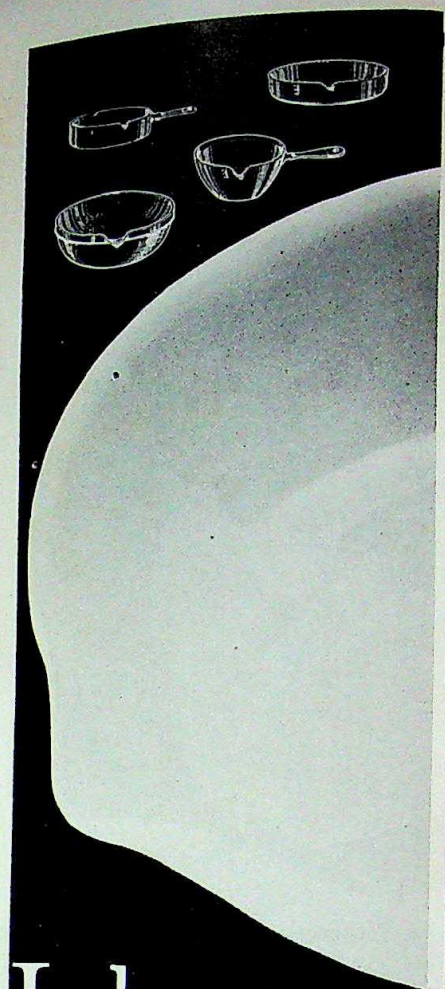

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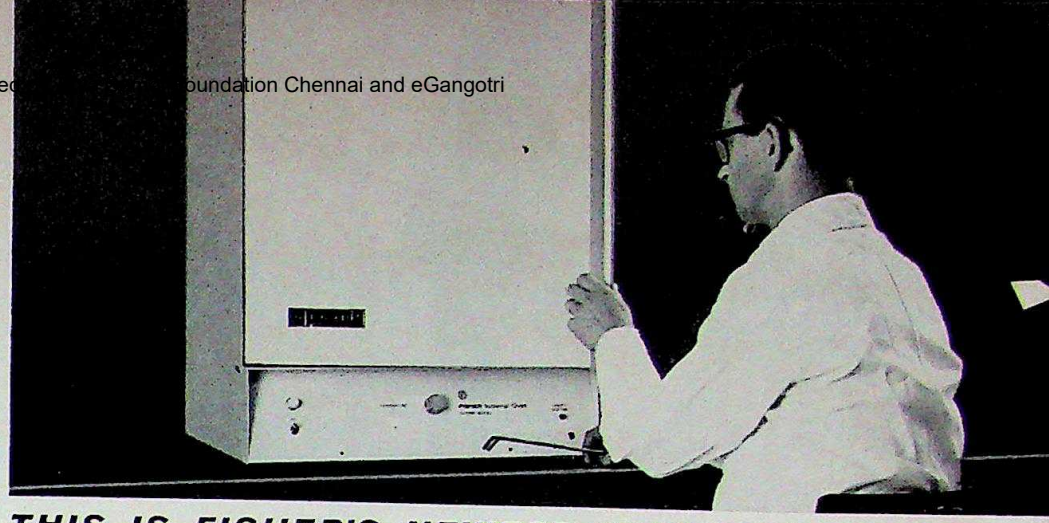

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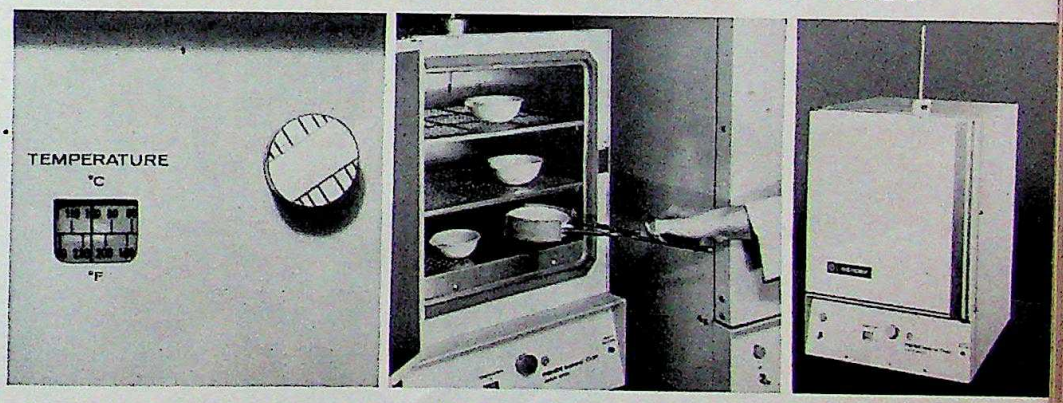

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His destination—E. Leybold's Nachfolger, where a line of world-famous high vacuum pumps is being manufactured for distribution in the U. S. through LaPine Scientific Company.

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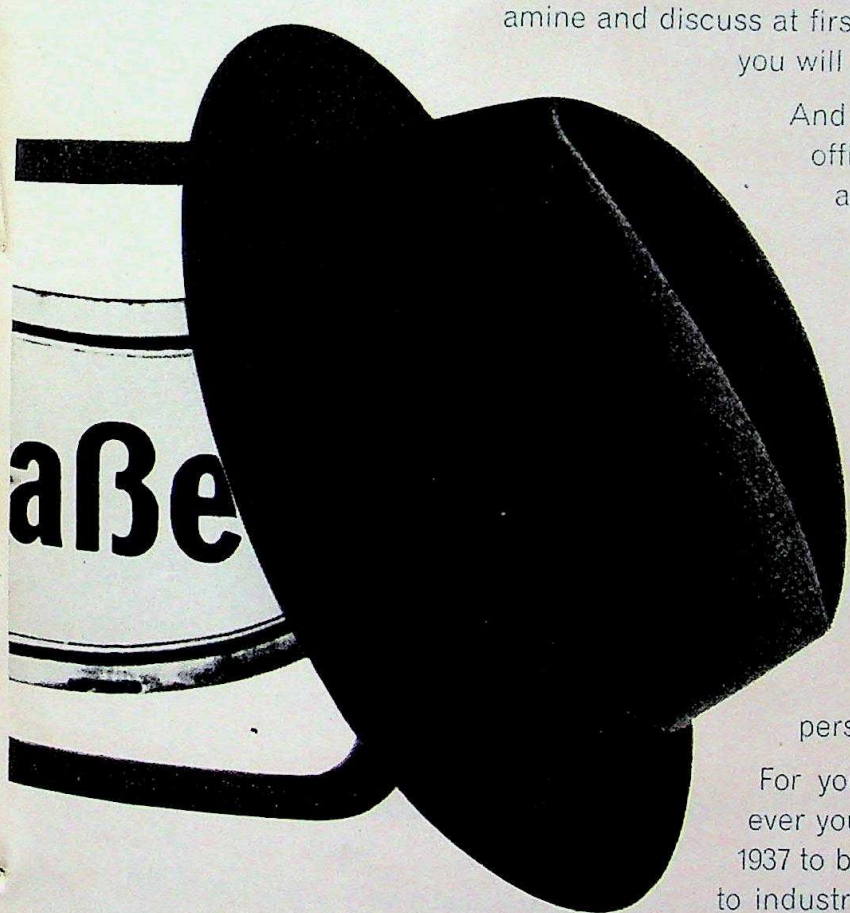

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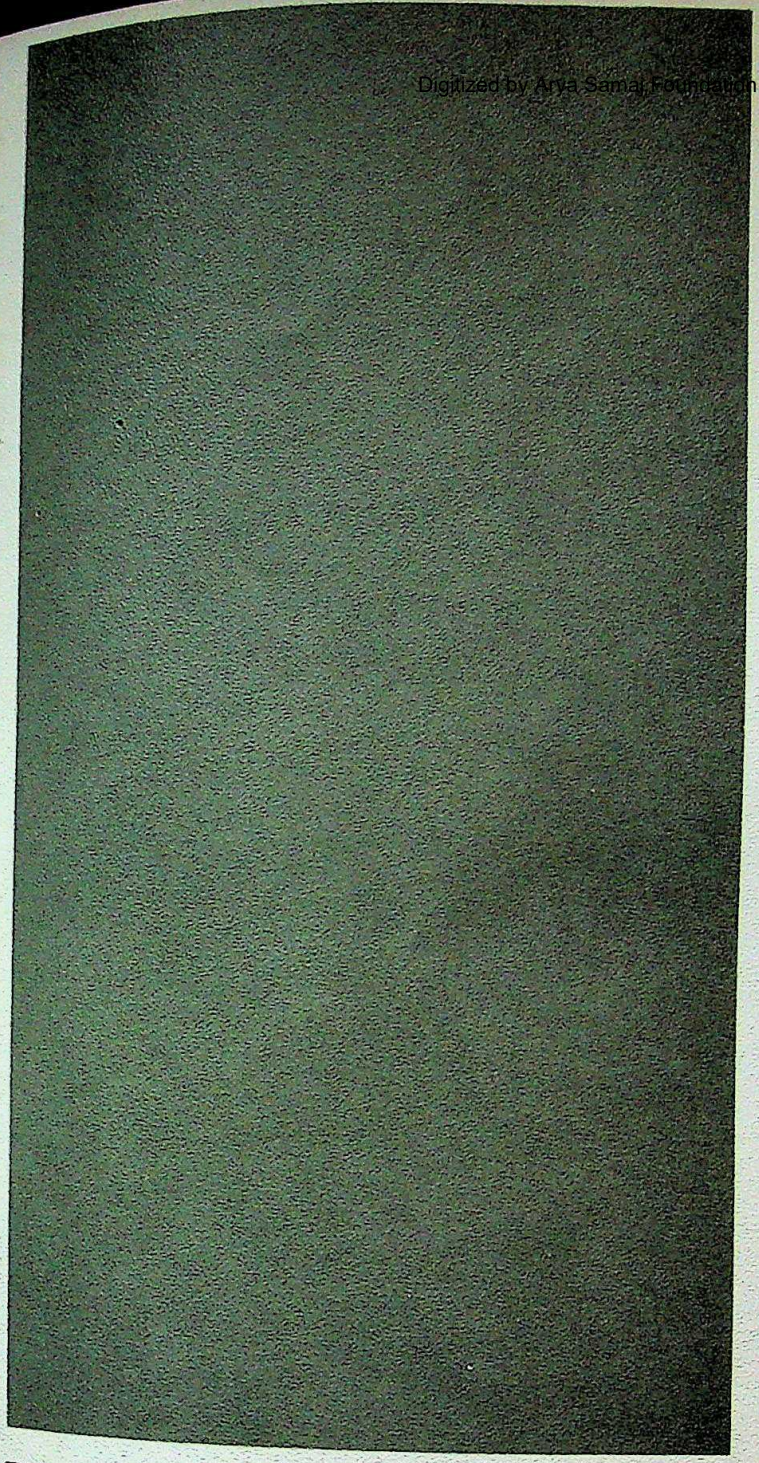

moduline

a new Aerograph series

Hy-Fl$_2$ • 202 • 1520

Will your next gas chromatograph be driveable?

The law requires that all new cars sold must be sufficiently complete to allow them to be driven. No such law protects the unwary gas chromatograph buyer.

You may need to buy, for instance, a storage battery, or for a small additional fee of $150—a built-in power supply. Flow controllers for two-column instruments will be provided for only $300. There are other little items which you can also dig up here and there, such as gas connecting tubes, filters, flow meters, septums, transformers, restrictors, etc.

As a sales inducement, Aerograph instruments are provided with those accessories necessary for its operation. A display of accessory items for the new Aerograph Hy-Fl$_2$ is shown on page 4.

The question is—who should take care of these little things?

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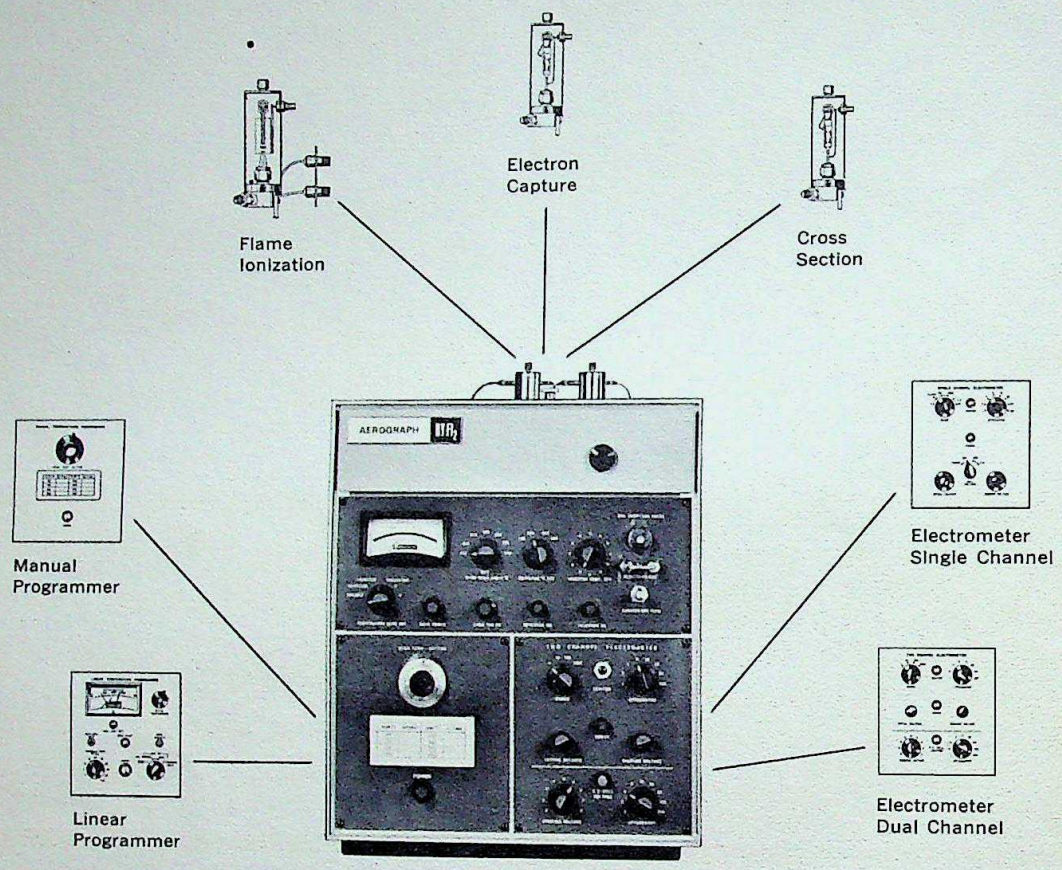
The Hy-Fl$_2$
with a single column and multiple detectors

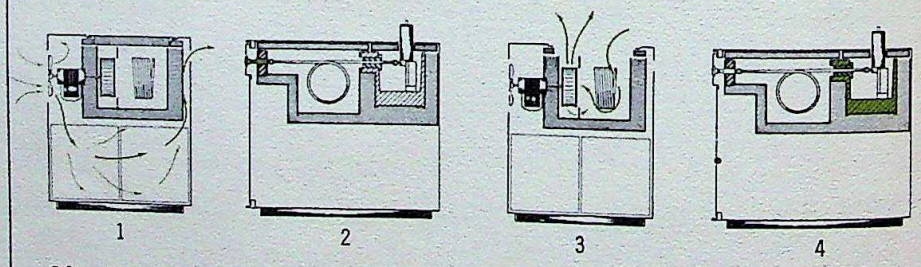


A modular concept provides the option to use and to interchange functional components.

The Hy-Fl$_2$, a single column gas chromatograph fulfills this requirement.

It may be used with any of the four common detectors or as a two-channel instrument with combination electron capture and flame detector. Either a manual or linear programming module may be selected.

Electrometers, single or dual channel, are interchangeable. Many accessories are available.



Single Cabinet Construction

1. Harmful heat from the ovens in the unitized cabinet is dissipated with a separate cabinet fan.
2. The short stainless steel injector permits on-column or vaporized injections to be made with standard Hamilton syringes with 2" needles.
3. The same motor circulates column oven air and also rapidly cools the column when the door is opened.
4. The column and detector ovens are thermally isolated from each other by glass wool and a moving air current.

Single cabinet construction saves valuable bench space, and allows permanent electrical connection to be made without cumbersome electrical cords and plugs necessary with the common multi- cabinet design.

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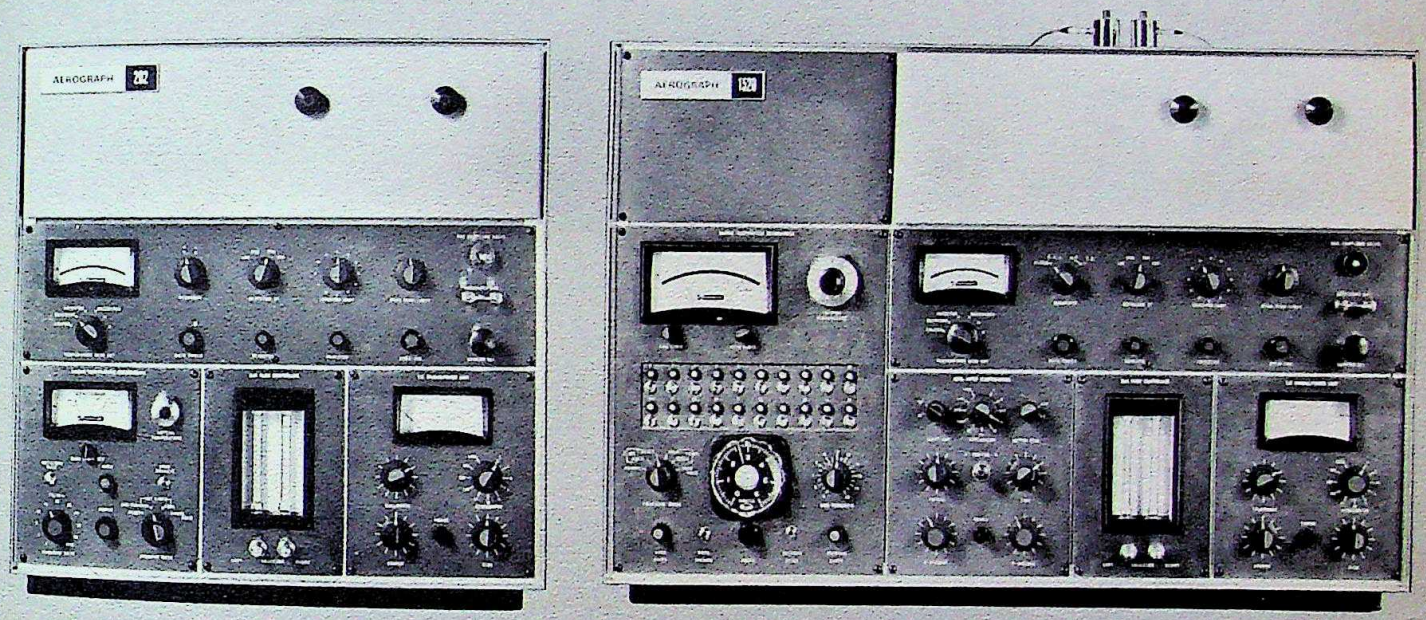
The 202 & 1520
with dual columns, and dual flame & TC detectors



Both the Aerograph 202 and 1520 Moduline instruments contain dual columns with proportional flow controllers and flow meters. The separate detector oven is precisely held at any temperature with full proportional heat control.

The all stainless column oven, heated by an 800 watt coil, will program at 30°C/min to 400°C and will cool from 400 to 100°C in four minutes.

The injectors are heated separately. Temperature readout on an accurate pyrometer reads column oven, injectors, detector oven, collector, and one auxiliary plug. An upper oven temperature limit control on all Moduline instruments protects columns and equipment from accidental overheating.

202

The Aerograph 202 incorporates either dual flame or dual input TC detectors. It may be used with the manual temperature programmer or the linear programmer (LP) modules. The LP is electronic without gears, motor, or clutch. A switch and matrix plug provide any programming rate desired.

1520

The 1520 is a more deluxe version of the 202. It contains both the dual flame and thermal conductivity detectors. The detector choice is made by re-connecting the downstream ends of the columns. The exclusive Aerograph matrix temperature programmer is standard. This deluxe programmer not only gives complete flexibility in pre-setting temperature programming rates but automatically closes the oven door after cool-down and re-establishes the start temperature.

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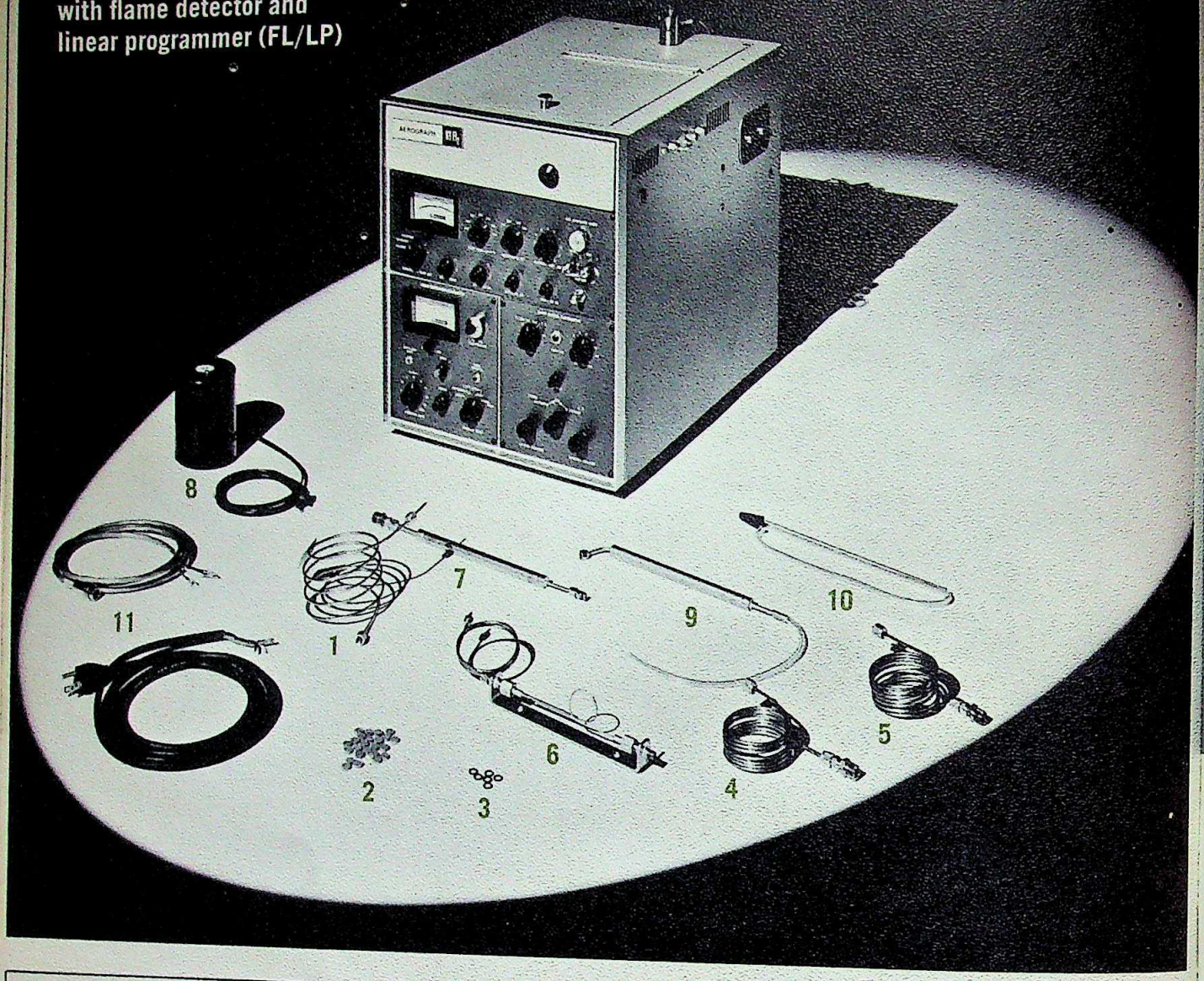
The Hy-Fl$_2$

with flame detector and linear programmer (FL/LP)



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This beautiful instrument comes with the accessory items shown above.

1. Stainless steel column (substrate optional)
2. 24 injection gaskets
3. 6 extra O-rings for flame tip
4. Hydrogen tank line, ⅛" copper, with fittings
5. Nitrogen tank line, ⅛" copper, with fittings
6. Restrictor, for regulating hydrogen flow rate
7. Nitrogen filter, stainless steel with molecular sieve
8. Air pump for air supply to flame
9. Air filter, stainless steel, molecular sieve
10. Soap bubble gas flow meter
11. Electrical cords for AC and recorder

You will also be interested in these bonus features standard with Moduline instruments.

- Separate detector oven, full proportional control
- 2" injector adaptable to Pyrex inserts and columns
- Special thermocouple and variable power plug for auxiliary equipment
- Capillary tube sample collection—with flame and EC detectors
- Differential flow controllers for carrier gas
- Many accessories, including hydrogen generator available

These new instruments are being described in current house publications, Aerograph Research Notes and Previews and Reviews. Write for your free Gurukul Kangri Collection, Haridwar subscription.

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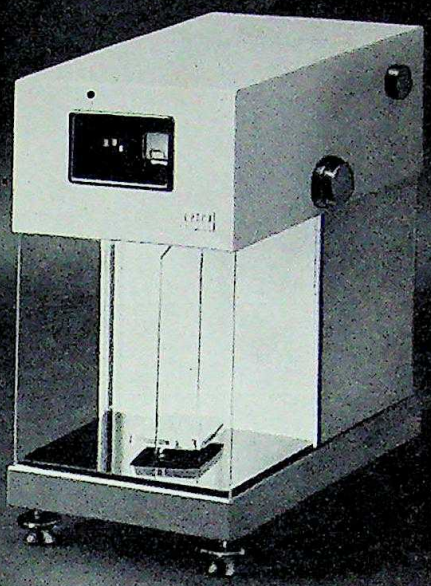

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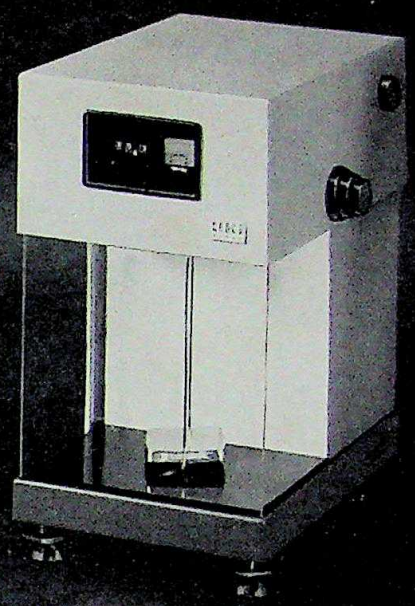

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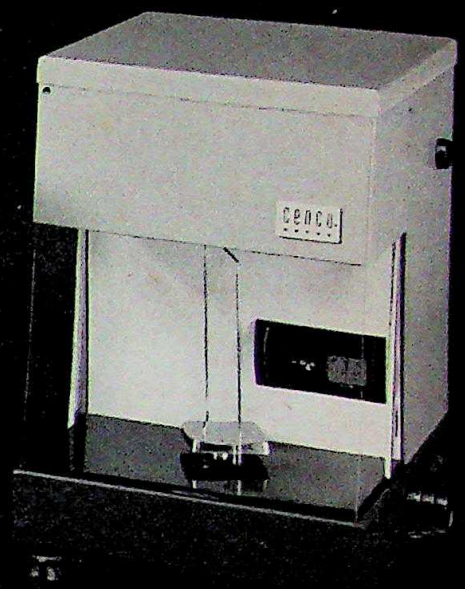

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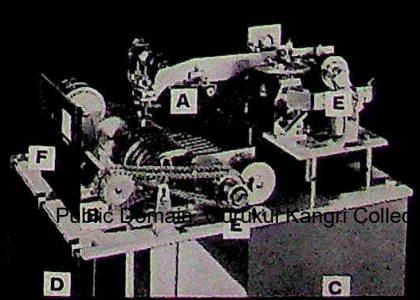

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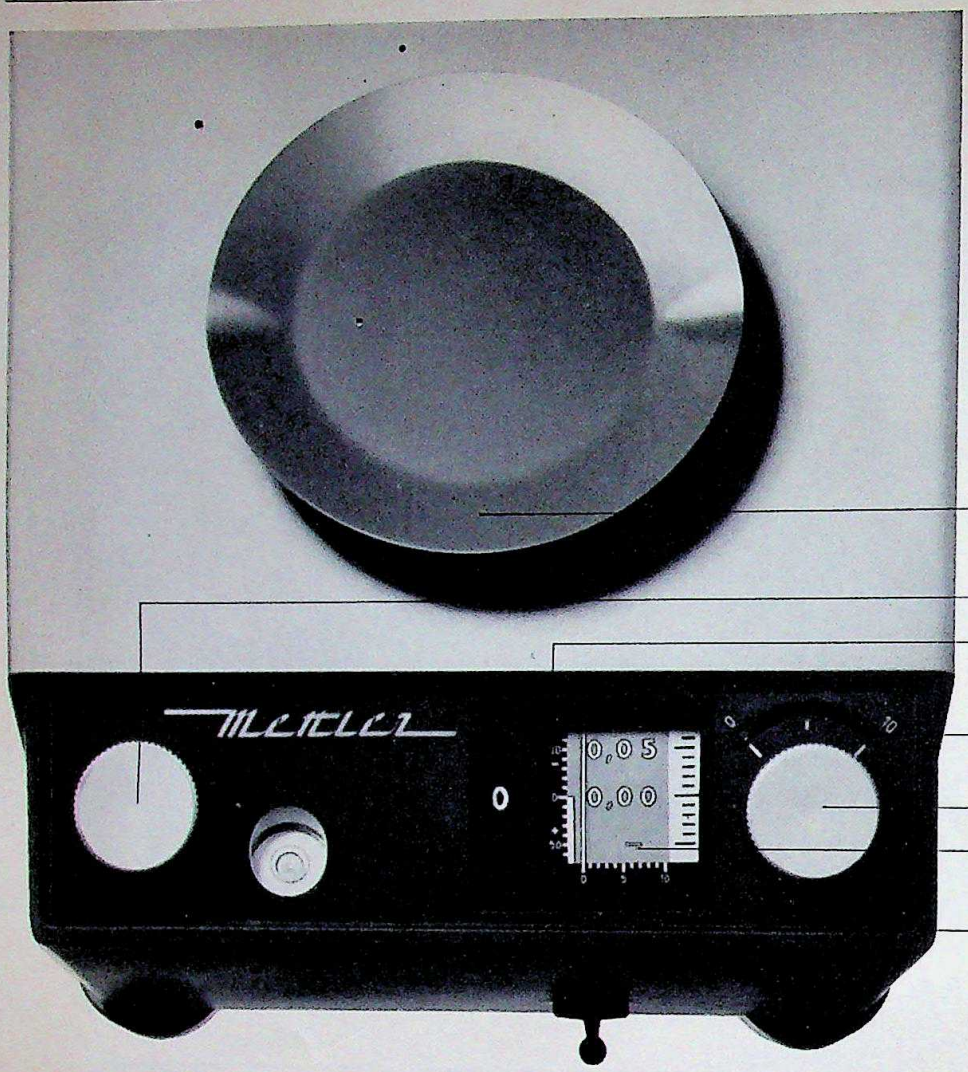

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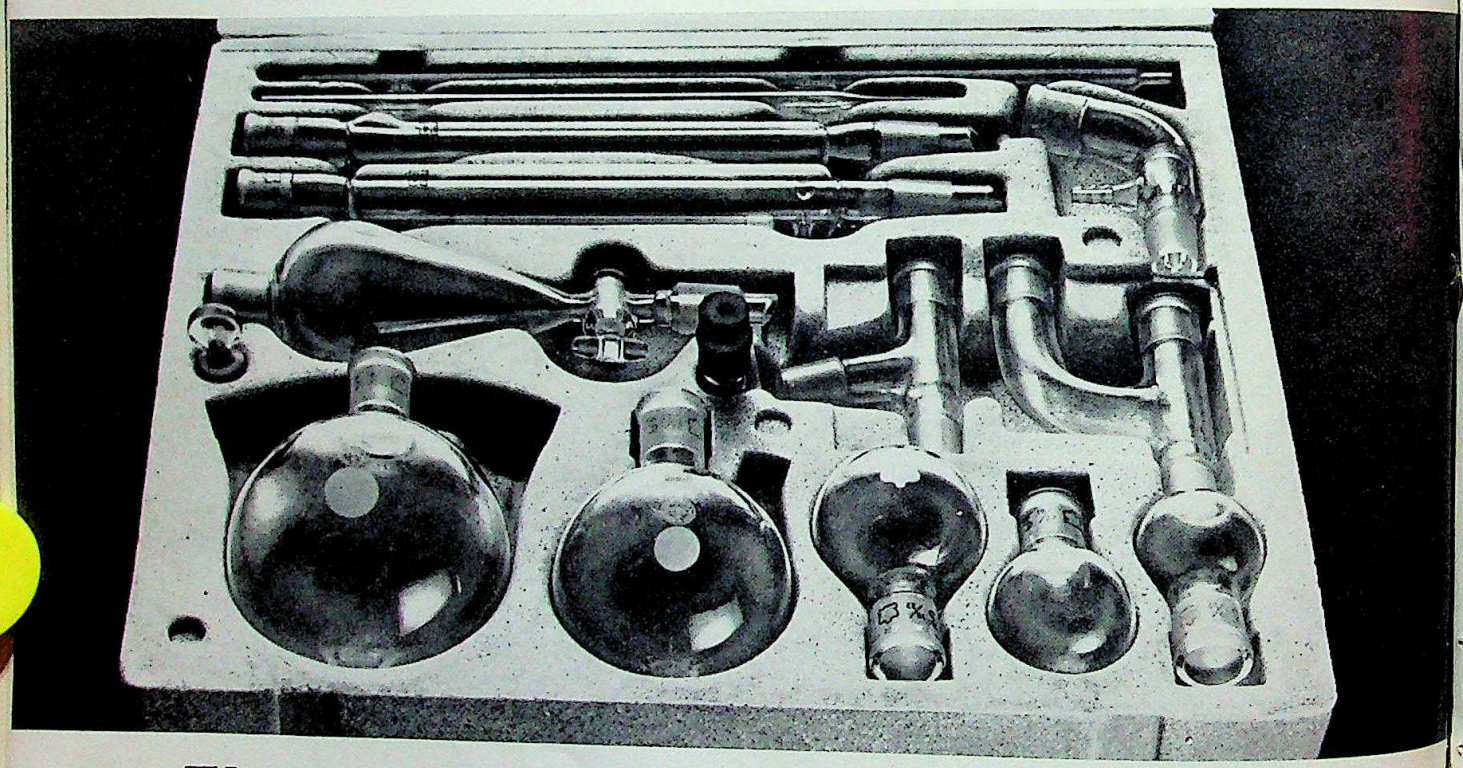
Corkless chem class . . .



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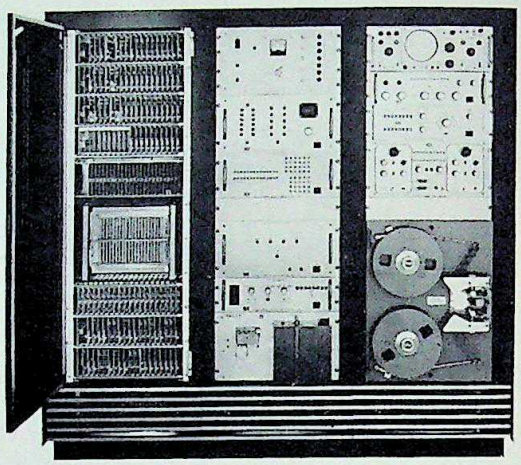
16,384-channel system with modular assembly permits adaptation of this system to varied requirements including simultaneous analysis of two sets of input pulses. Plug-in input units are provided for selection of Pulse Height or Time-of-flight analysis in either of two parameters. Data are displayed on a CRT in "map", "isometric", or "slice" modes. Data may be stored in many sub-groups, either manually or by external routing signals.

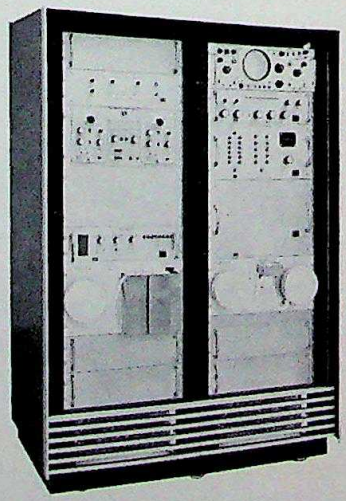
Basic Components: 2-parameter Input Unit with logic plug-ins for PHA or TOF; Coincidence Detection Unit; Memory Control Unit; 16,384-channel ferrite core Memory; Display Control; Automatic Programmer; Readout Equipment.



Multi-parameter Analysis

4096-channel system with modular construction includes the two-input unit with logic plug-ins for 2-parameter coincidence or singles studies — Pulse Height Analysis, Time-of-flight or both. Digital baseline and range switching permits up to 256X magnification of a selected area of the spectrum. For example, the experimenter can select various 4096-channel address configurations from a 1024 x 1024 (mega-channel) spectrum.

Basic Components: 2-parameter Input Unit with PHA or TOF plug-ins; Memory Control Unit; 4096-channel Memory; Coincidence Unit; Format Selector; Display Control; Automatic Programmer; Readout Equipment.



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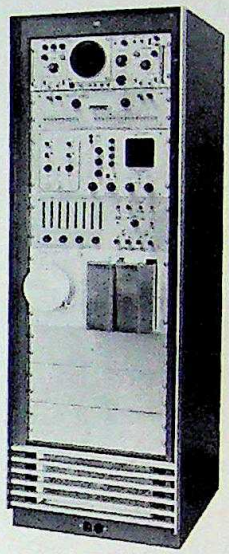
Multi-purpose Pulse Analysis

Model CN-1024, 1024-channel pulse analyzer provides a choice of interchangeable plug-in logic units for rapid conversion to different types of Pulse Height analysis; Time-of-flight studies; Pulsed Neutron studies; Mass Spectrometer analyses; Multiscaler operation; or Coincidence Pair Spectrometer operation. Display Control Unit, when used with Coincidence Pair Spectrometer plug-in, provides significant "map" display of data.

- **Basic Components:** 1024-channel Memory; Logic Plug-ins; Display Control Unit; Data Output Unit; Readout equipment.

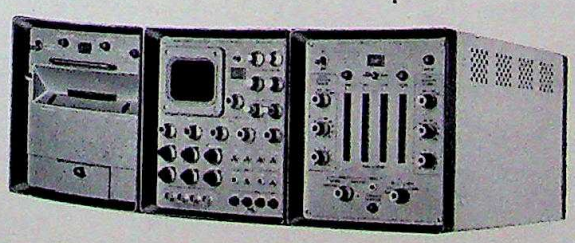


Multi-purpose Pulse Analysis

Model CN-110, 256-channel multi-purpose pulse analyzer employs interchangeable plug-in logic units identical to those used in the CN-1024 system: Pulse Height Analyzer; Time-of-flight; Pulsed Neutron; Multiscaler; Mass Spectrometer; Coincidence Pair Spectrometer. Provides for analog, digital, and binary readout with various accessory equipment. Totally transistorized circuitry on plug-in cards results in compact, bench-top size and 25-watt power requirements. Accessories include Data Output Unit, and numerous readout control devices.

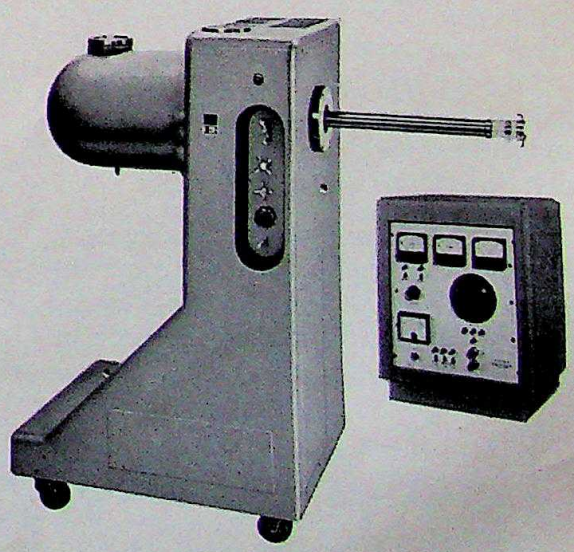
Portable Multi-channel Analysis

Model 404, 4-input, 400-channel pulse analyzer with accessory Resolver/Integrator and high speed printer. The versatile portable 400 Series analyzer is ideally suited for activation analysis and similar identification applications. It provides for data storage in memory groups of 1 of 400 channels, 2 of 200 channels or 4 of 100 channels ∴ data transfer from half to half or quarter to quarter in the same half. 3″ CRT provides analog display. Analyzer is compatible with paper tape punch, reader, IBM typewriter and digital printer readout devices. **Resolver Integrator** has push-button operation, performs as resolver or integrator without need for intermediate tape equipment. As a resolver it makes data available from any analyzer memory quarter or half and adds to or subtracts from data in adjacent quarter or half. Permits removal of individual components of a spectrum. As an Integrator, it integrates memory data within any channel band from 0 to 399 in either of two modes. **Printer unit** prints out channel no. and data at high speed — 5 lines per second — on 3-inch paper tape. Built-in high voltage supply will power as many as four detectors.



Neutron Generator for Activation Analysis

Ellison Activatron-110, 150 KV neutron generator is a simple, effective, low cost unit that will produce 14 MEV neutrons from a Deuteron-Tritium reaction. Neutron yield is greater than 10^{10}n/sec. Uses unique ion source derived from 150 KV accelerating voltage which permits entire ion source and accelerating tube to be immersed in an oil tank. Compatible with TMC 400 series pulse analyzer and accessory units.



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$1.24/PT. $1.24/PT. $1.19/PT.

To Chemists who think that Merck quality costs extra

It doesn't. Merck Chemicals may set the standards that others attempt to follow—but who can put a price tag on quality? In fact, there are many examples where Merck customers actually *save* money, and still do not have to sacrifice the extra quality. A quick look at the comparative price chart will show you that it really pays to specify Merck when ordering standard chemicals. And if your need is for something special, again it is smart to specify Merck. The production of specific chemicals for specific analytical jobs is a Merck specialty.

For your copy of the Merck Laboratory Chemicals Catalog, plus the name and address of your nearest Merck supply house, write to: Quinton Company, Division of Merck & Co., Inc., Rahway, N.J.

MERCK CHEMICALS SAVE YOU MONEY

FOR EXAMPLE:

PRODUCT	SIZE	Consumer Prices Per Pt. MERCK	BRAND B	BRAND M
Chloroform Reagent (A.C.S.)	5 pt.	$1.19	$1.24	$1.24
Acetone Reagent (A.C.S.)	8 pt.	$ .48	$ .54	$ .52
Methyl Alcohol Anhydrous Reagent (A.C.S.)	8 pt.	$ .44	$ .48	$ .48
Isopropyl Alcohol Reagent	8 pt.	$ .51	$ .56	$ .53
Carbon Tetrachloride Reagent (A.C.S.)	5 pt.	$ .97	$1.05	$1.00
Toluene Reagent (A.C.S.)	8 pt.	$ .45	$ .49	$ .48

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Out of the EDITOR'S BASKET

Edited by William G. Kessel

When writing for additional information about new products or for new literature, your inquiry will receive prompt attention if you write on your firm or Institution letterhead and mention the Journal of Chemical Education and the date of the particular issue. Pamphlets, booklets and similar literature are gratis unless otherwise specified.

New Apparatus and Equipment

▶ A complete line of Absorption Cells for spectrophotometers manufactured in the Common Market is being imported by Scientific Cell Company. The line includes standard rectangular and cylindrical types as well as flow cells, semimicro, and microcells. They are of completely fused construction, matched into sets of two or four and color-coded for ease of identification. The Cells are available for measurements in the far-ultraviolet range down to 165 millimicrons, through the ultraviolet, the visible, near-infrared, and the infrared ranges up to 3.6 microns. Descriptive bulletin, price sheet, and name and address of your local SCC distributor are available from Scientific Cell Co., 70–20 Austin St., Forest Hills, New York 11375.

▶ For complete information on IEC Maxiforce bottles for high speed, high volume centrifugation, and other plastic containers write to International Equipment Co., 300 Second Ave., Needham Heights 94, Massachusetts.

▶ Gerald K. Heller Co., P.O. Box 4426, Las Vegas, Nevada, offers a new S-250 solid state motor controller. Input voltage 208–240 a.c., single phase with output of 200 v dc, for field.

▶ Carl Zeiss, Inc., 444 Fifth Ave., New York 18, N. Y., announces the availability of the particle size analyzer TGZ 3, providing the highest degree of automation possible for the analysis of all particles in a mixture, including those which overlap or are irregularly shaped. In a typical mixture, 1000 particles can be analyzed in 48 different size categories in approximately 15 min.

▶ Linayer Corp., 201 Ford Building, Detroit 28, Michigan, offers a series of versatile instruments called "Quantab." They are available to measure rapidly, concentration of salt and total acidity and alkalinity in various ranges.

▶ Techne Ltd., 661 Brunswick Pike, Princeton, New Jersey, has available the "Tempette" for applications requiring temperature control in the range of 2 tenth of 2 degree.

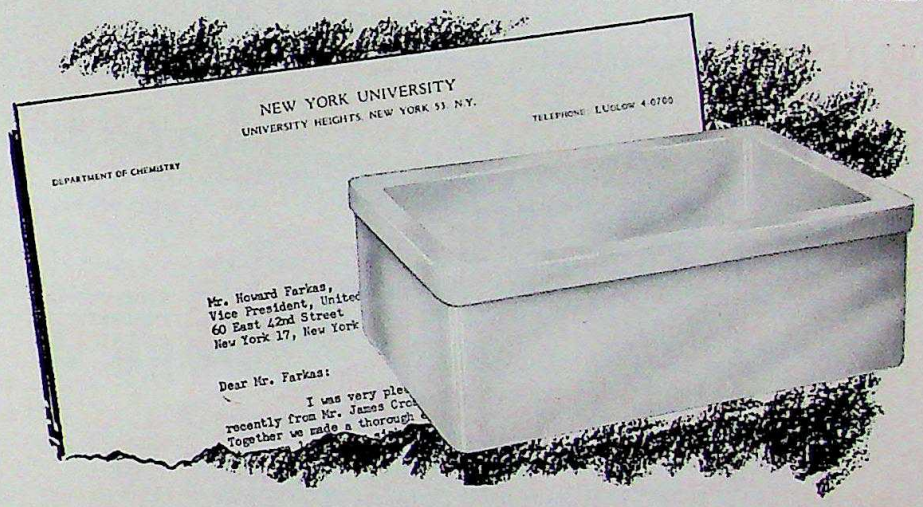
▶ Any isothermal gas chromatograph now can be easily converted into a versatile, dual column temperature programmed instrument by adding the new, low-cost Loenco Model 150 oven accessory. Write for Data Sheet LOE-21—Loenco, Inc., 2092 N. Lincoln Ave., Altadena, California.

▶ Aero Geo Astro Corp., Lincolnia and Edsall Rds., Alexandria, Virginia, offers a new differential controller as an economical means of obtaining precise temperature control in laboratory enclosures.

▶ A special hand-operated, deck-top emergency spray has been designed by Haws Drinking Faucet Co., 4th and Page Sts., Berkeley, California, for immediate first aid to counter eye, face and body contamination. Haws Model 8902 is designed for the laboratory or classroom where work with potentially dangerous chemicals or fire is involved.

▶ A new low priced precision 6 inch electromagnet, specifically designed for research applications, is now available from Alpha Scientific Laboratories, Inc. P.O. Box 333 Berkeley 1, California. The design incorporates a one piece frame, cast of high grade magnet steel, to provide a field of 8000 gauss in a 2 in. gap with 6 in. pole faces, and 12,000 gauss with a $^3/_4$ in. gap.

(*Continued on page A874*)



"practically indestructible"...

. . . that's the way Dr. E. J. Durham, director of New York University's Nichols Laboratory describes U. S. Stoneware lab sinks. Today, after more than 35 years of service, the "U. S." lab sinks installed when Nichols Laboratory was built are just as good as new. Not one has ever had to be replaced.

N.Y.U.'s experience is typical of that of several thousands of users of "U. S." Chemical Porcelain Laboratory Sinks — users whose sinks will, almost without exception, outlast the buildings in which they are installed.

Time-proven "U. S." Chemical Porcelain Lab Sinks will handle safely all acids, alkalies, caustics and solvents— weak or strong, hot or cold. Thus, there's no need for corrosion charts . . . no need for special sinks for special corrosives.

Mechanically strong and rugged, "U. S.' Chemical Porcelain sinks will stand up under all the heat-shock and physical abuse they'll ever meet in ordinary lab usage. Non-staining and scratch-resistant, they're as easy to clean as a china dish. And . . . they're available in three attractive colors to match any decor.

Your Laboratory Furniture Manufacturer can give you complete information. See him, or write for your free copy of Bulletin L-10.

Chemical Ceramics Division

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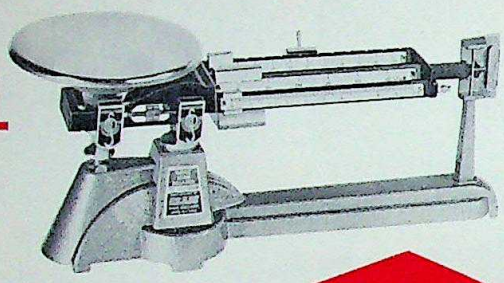
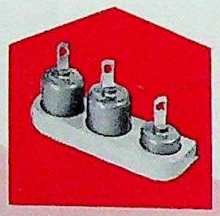
TRIPLE BEAM BALANCE

MODEL 760 with undivided tare beam



LIST PRICE $24.50 w/o att. weights



MODEL 707 ATTACHMENT WEIGHTS $5.50

ONLY OHAUS HAS 2610 GRAM CAPACITY BUT . . .

There are many other reasons why those who weigh their decisions carefully SPECIFY OHAUS! Here is a precision balance suited to a wide range of general laboratory and industrial applications. Exclusive OHAUS versatility makes available undivided tare beam and poise, avoirdupois standards, plus a choice of commodity platters. Choose plate, removable pan or scoop of stainless steel or even a 9″ dia. x 5″ deep animal subject box. Stainless Steel relief etched tiered beams, and epoxy enamel finishes assure maximum corrosion protection. Readings are faster with true sliding type poise which eliminates secondary beam oscillations. Readings are more accurate because end reading device eliminates parallax error. Add these to other features experience has taught us you demand and we are confident you will also choose OHAUS . . .

94 the LEADER WHO INVITES COMPARISON!

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OHAUS SCALE CORPORATION
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Dept. KE

Out of the EDITOR'S BASKET

▶ F & M Scientific Corp., Avondale, Pennsylvania, announces the availability of a new component collection system for gas chromatography. Designated the Model TCS-3, the unit represents a significant advance over previous collection methods since it allows 100% positive collection of both the component effluent and carrier gas and is not dependent upon the condensation of a solute from a moving gas stream.

▶ Digital, eyelevel readout and an illuminated auto-indicating vernier are featured in the Model 160 B high speed, single pan analytical balance recently made available by the Voland Corp., 27 Centre Ave., New Rochelle, New York.

▶ Two new low-cost gas chromatographs Model 810 and 820 of unusual flexibility and performance have been announced by Perkin-Elmer Corp., Norwalk, Connecticut. For many applications, the instruments are said to be fully as useful as units of twice their cost.

▶ Literature, samples and prices of a new steel tubing clamp for laboratories, is available from Penn-Chem Corp., 232 N. Marshall St., Lancaster, Pennsylvania.

▶ A new combination gas chromatograph and gas thermal conductivity analyzer has been developed by Atomic Laboratories, Inc., 3086 Claremont Ave., Berkeley 5, California. Designed primarily for demonstration purposes in the science classroom and laboratory, the instrument can also be used for various chemical research and analyses.

▶ An analytical balance with 1200 mg. optical range, plus or minus 0.05 mg. precision, and direct reading to 0.1 mg. has been introduced by Mettler Instrument Corp. 20 Nassau St., Princeton, New Jersey, for laboratory, production control and school application.

▶ A new, low cost data acquisition system has been announced by Bausch & Lomb, Rochester 2, New York, providing a rapid, precision method for analyzing and recording colorimetric samples. The inherent accuracy of the system is due largely to the fact that component units have been specifically designed to function together in an integrated manner. As a result, ease and speed of operation permit technicians to produce a valid record in a matter of seconds.

▶ The Houston Instrument Corp., 4950 Terminal Ave., Bellaire 101, Texas, offer the HLVC-150 log voltmeter converter which gives accuracy over a 70 db range. 70 Db corresponds to a range of 1 mv to to 3.16 v or 100 mv to 316 v; either range is selectable with an attenuator.

▶ Applied Research Associates of Texas, Inc., 6541 N. Lamar Blvd., Austin 5,

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Texas, offer a remote measurement electronic thermometer. Remote 6 sec liquid temperature measurement to 1° accurate to 500 ft is convenient with the Model FT-2 ARA electronic thermometer.

▶ A miniature precision air sample pump has been developed and perfected for personnel monitoring and atmospheric sampling. Model S440 miniature sampler is powered by a 6 v rechargeable nickel cadmium battery capable of 8 hr. of continuous sampling. Write Union Industrial Equipment Corp., Port Chester, New York, for information.

▶ A compact new combined temperature/power-control center with proportioned output is now being produced by the Research, Inc. Controls Division, P.O. Box 6164, Minneapolis, Minnesota. The complete control module consisting of a temperature-indicating pyrometric controller and a solid-state power proportioner is called the Thermac Model MPR 7822.

▶ The General Scientific Equipment Co. has announced a new line of heavy-duty unit first aid kits designed to facilitate emergency treatment through the use of unit-wrapped items, boldly labeled and arranged for immediate recognition and access.

Each G-S Unit-Type Kit has a facsimile index on the inside of the case lid which shows at a glance the exact location of all items and gives concise instructions for their use.

Cases are made of 20-gauge steel, finished in either olive green or grey baked-on enamel. Integral mounting brackets and carrying handle permit the kits to be used for permanent wall installation or portable service.

Complete information may be obtained by requesting Bulletin 305 from General Scientific Equipment Co., 7516 Limekiln Pike, Philadelphia 50, Pennsylvania.

▶ A nearly maintenance-free electric steam boiler has been developed by the Hot-Shot Division, Automatic Steam Products Corp., 3-7 W. 61st St., New York 23, N. Y. The new Hot-Shot electric boiler was developed for the Oak Ridge National Laboratory for use in a distillation process to produce Oxygen 17—a "clean" isotope used in bio-medical research. The distillation process at Oak Ridge is expected to run night and day for two or three years before production of Oxygen 17 begins at full enrochment. The Hot-Shot boilers were designed to run for 26,280 hr in continuous operation without being shut down for maintenance. Detailed information about these boilers is available by writing to the Hot-Shot Division.

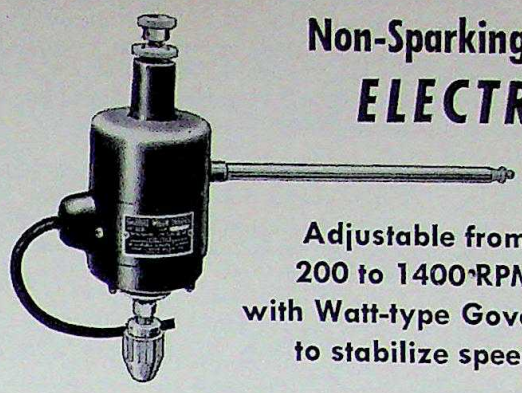
▶ Phoenix Precision Instrument Co. announces a new color-monitoring device for continuous flow applications. The

(*Continued on page A876*)

MAXIMUM SAFETY PROVIDED WITH THE WELCH

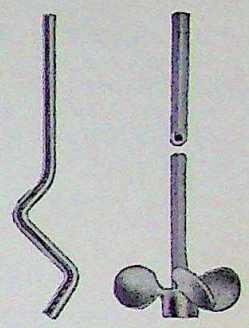
Non-Sparking—Speed Controlled

ELECTRIC STIRRER



Adjustable from 200 to 1400 RPM with Watt-type Governor to stabilize speed

Adjustable Chuck for stirring rods up to 1/4-inch diameter



No 5230M. No. 530R.

An Ideal General Purpose Stirrer

INDUCTION TYPE MOTOR

No brushes or commutator

• QUIET OPERATION

No. 5230. ELECTRIC STIRRER. For 115 volts 50/60 cycles A.C. **Each $58.50**
No. 5320A. ELECTRIC STIRRER. With stepdown transformer, for 230 volts 50/60 cycles A.C. **Each $64.50**

STIRRING RODS

No. 5230G. GLASS STIRRING ROD. Double V form, for No. 5230 or No. 5230A Stirrer. **Each $0.90**
No. 5230M. MONEL STIRRING ROD. Double-V form, for No. 5230 or No. 5230A Stirrer. **Each $2.50**
No. 5230R. POLYETHYLENE STIRRING ROD. Propeller-blade form, for No. 5230 or No. 5230A Stirrer. **Each $1.80**

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ESTABLISHED 1880
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New York Office: 331 E. 38th St., New York, N. Y. 10016
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FOR SIMULTANEOUS REDOX AND pH DETERMINATIONS AND DEMONSTRATIONS

Includes the Analytical Dual Probe Redox-pH Meter, Titra-Stand, probe units, buffer kit, burettes and holder — all at one low price. Write for Bulletin TK.

Analytical Measurements, Inc.
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Out of the EDITOR'S BASKET

Phoenix Flow-Colorimeter Model 600, was especially designed for monitoring of column effluents in chromatographic applications, where wide concentration ranges and minimum mixing are of major importance. This instrument incorporates a voltage stabilizer, a filter turret for convenient change of monochromatic filters, a dual-sensitivity glass absorption cell, a precision cell positioning device and a 570 mμ peak wavelength interference filter. A 10-turn shunting potentiometer for full scale adjustment of the photocell output signal is also incorporated. The Flow-Colorimeter can be used with almost every commercially available indicating or recording device.

For further information, write to: Phoenix Precision Instrument Co., Inc., 3803–05 N. Fifth St., Philadelphia 40, Pennsylvania.

▶ For information regarding a new line of Cenco single stage Hyvac pumps and liquid air traps write to Central Scientific Co., 1700 W. Irving Park Rd., Chicago 13, Illinois.

▶ The Schuco semi-micro glassware line provides simple, compact sets ideal for school use, to sets giving over 20 different assemblies for the postgraduate course and research workers. Write Schuco Scientific, 250 W. 18th St., New York 11, N. Y.

▶ Originally designed for advanced biochemical research at the University of Southern California's Department of Microbiology, the new Beckman DK-Universal spectrophotometer is now available from the Scientific and Process Instruments Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, California.

Haws EMERGENCY Eye-Wash provides instant first aid to prevent serious injury due to eye contamination

. . . by saving those vital seconds that can mean the difference between temporary irritation and permanent injury. Controlled streams flood the eyes, washing away searing chemicals and other foreign matter. See this model and others, as well as emergency drench showers, detailed in the Haws Safety Equipment Catalog. Write today to Haws Drinking Faucet Company, 1443 Fourth Street, Berkeley 10, California.

HAWS EYE-WASH FOUNTAINS

Since 1909, designers and manufacturers of drinking fountains and water coolers.

New Literature

● For information on a new electric timer, designed for starting and stopping equipment during a long weekend or holiday write Labline Instruments, Inc., 3070 W. Grand Ave. Chicago 22, Illinois. Ask for *Bulletin 637*.

● For information on the Model RMU-6A Hitachi Perkin-Elmer mass spectrometer, write: Instrument Marketing Division, Perkin-Elmer Corp., Main Ave., Norwalk, Connecticut.

● Texas Nuclear Corp., P.O. Box 9267 of Austin 17, Texas, has introduced a complete activation analysis laboratory, the Model 9601. It includes irradiation, sample handling and counting equipment, all designed and manufactured by a single, integrated manufacturer. Ask for the *Bulletin* on this equipment.

● A new 4-page Norelco brochure, giving complete engineering data on miniature Cryogenerators for research, medical, aero-space, communications, defense, biological and industrial applications, is available from Cryogenerators, Division of North American Philips Co., Inc., Mendon & Angell Rd., Ashton, Rhode Island.

● Complete information on all five types of Corning GlassPlants and their applications are available in one brochure from Corning Glass Works, Corning, New York. The brochure is a composite of five separate booklets that explain in text, drawing and photographs the operation of GlassPlants, the all-glass chemical processing modular units for production, pilot plant or laboratory uses.

● A new 16-page products *Bulletin 100-G* listing all chemicals commercially supplied by Hooker Chemical Corp., Niagara Falls, New York, and subsidiaries is now available on request.

● Copies of the *Industrial pH Handbook* Bulletin ph-4035 may be obtained by writing to the Technical Information Department, Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, California.

● The versatility of the Reichert research microscope "Zetopan" is described and illustrated in a ten-page folder. Write to William J. Hacker & Co., Inc., P.O. Box 646, West Caldwell, New Jersey.

(*Continued on page A878*)

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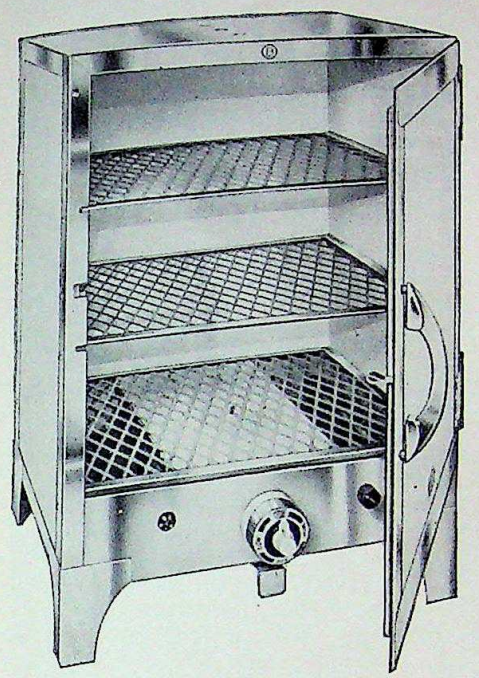
Boekel LABORATORY OVENS

for Sterilizing, Drying, Conditioning, Preheating, etc.

UNEXCELLED for PERFORMANCE and DURABILITY



No. 1078A

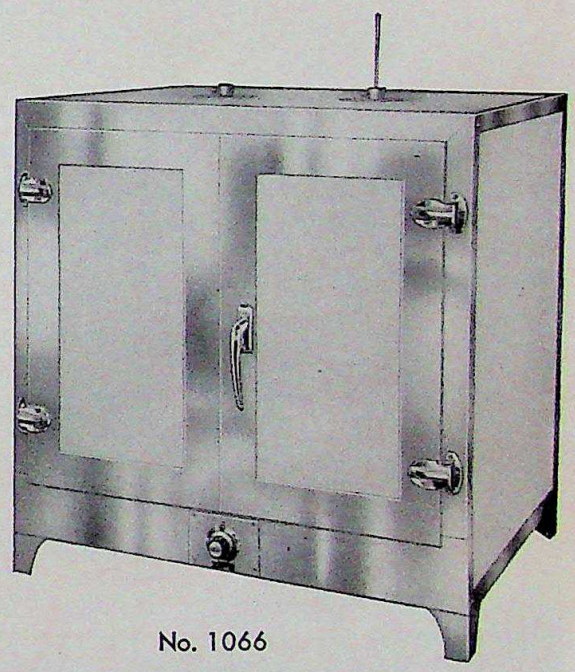
THE WORLD-POPULAR 1078A DRYING OVEN—*provides these features:*

• Polished stainless top and control panel. • Polished stainless steel framework. • Strong spotwelded frame. • Set-in door construction. • Rigid high-insulation-value walls. • Adjustable bottom ventilators. • Bimetallic thermostat, control switch and pilot light. • Working chamber inside 18¼″ high x 17″ wide x 14¼″ deep. • Explosion proof door catch with streamlined chrome handle. • Galvanized expanded metal shelves, bound with stainless steel. • Overall outside dimensions 25-⅝″ x 18¼″ x 17½″ deep. • Heavier insulation; temperature range to 200°C. • 1500 watt heaters. • AC only—specify 115 volt or 230 volt.

SMALLER SIZE 1078—*or, 1078G, with heat-resisting glass door:*

• Asbestos door, stainless steel top and frame. • ⅜″ thick Marinite for temperatures up to 200°C. • New bimetallic thermostat mounted in heating area for better sensitivity and easy adjustment. • Temperature control ±1°C. Inside dimensions, usable space 9″ high x 11¼″ wide x 9½″ deep. • Outside dimensions 14-¾″ high x 12¼″ wide x 11½″ deep. • 660W heating units located in bottom, readily accessible for replacement or changing from 115 V. to 230 V use. • Supplied with a three-wire cord and plug. • AC only—specify 115 volt or 230volt.

A Long-Term Investment for laboratories, Boekel Constant-Temperature Ovens offer many desirable features, such as: Corrosion Resistant Polished Aluminized Steel or Stainless Steel spot-welded bodies and frames with asbestos exterior panels. • Double Wall Construction with non-settling rock-wool insulation. • Uniform Heat Distribution by strategic location of coils and efficient baffling . . . coils operate at black heat for maximum efficiency and longer life. • Constant Temperature within range 35° to 200°C maintained by Robertshaw hydraulic thermostat . . . sensitivity ±1°C. • Individual On-Off Switch permits maintenance of thermostat setting for succeeding tests. • Strong, Well Supported, Insulated Doors with positive locking door, two-point latch and thick asbestos gasket, minimizes heat loss. • Sturdy, Heavy Gauge Shelves are self-supporting even when partially withdrawn.



No. 1066

TWO METALS AND THREE SIZES TO CHOOSE FROM:

No. 1066 Double door. Aluminized steel. Inside dimensions: 25″ high x 31″ wide x 19″ deep. Outside dimensions: 38½″ high x 38″ wide x 28¼″ deep. Capacity 8.5 cubic feet. Three removable shelves. Consumes 2000 watts.

No. 1066S. Same as 1066 except all metal parts of stainless steel.

No. 1065 Single door. Aluminized steel with all metal door. Inside dimensions: 12″ high x 12″ wide x 12″ deep. Outside dimensions: 24½″ high x 18″ wide x 19″ deep. Capacity 1 cubic foot. Two removable shelves. Consumes 600 watts.

No. 1064 Single door. Aluminized steel. Inside dimensions: 18″ high x 24″ wide x 14″ deep. Outside dimensions: 32″ high x 31½″ wide x 21″ deep. Capacity 3½ cubic feet. Two removable shelves, one stationary. Consumes 1200 watts.

No. 1064S Same as 1064 except all stainless steel including entire door.

ALSO AVAILABLE

GAS-HEATED, HOT AIR STERILIZERS—made of stainless steel (triple wall), thermostatically controlled. Further information on request.

No. 217

WRITE FOR COMPLETE INFORMATION—ORDER THROUGH YOUR DEALER

BOEKEL PRODUCTS ARE KNOWN BY THE TRADE MARK (B) DISTRIBUTED THROUGH LABORATORY SUPPLY DEALERS

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Out of the EDITOR'S BASKET

● *Facts & Methods For Scientific Research* is available from F & M Scientific Corp., Avondale, Pennsylvania. The Spring issue (Vol. 4 No. 2) consists of twelve pages devoted to new applications and techniques in analysis by gas chromatography.

● A sixteen page illustrated brochure *Bulletin No. AC-6297* that describes the Series 350 digital operation system is available from Electronic Associates, Inc., Long Branch, New Jersey. This computer is the digital portion of the Hybrid 2000, a hydrid digital/analog computer.

● *Bulletin SR-3* illustrates and describes in detail the three SR-type recorders from the designer and manufacturer, E. H. Sargent & Co., 4647 W. Foster Ave., Chicago 30, Illinois: Model SR and Models SR-20 and 30 and Model SRL.

● A new 6-page Norelco folder titled *X-ray Microscopy in Sharp Focus*, giving operating principles and application data for such instruments, is available from Philips Electronic Instruments, 750 S. Fulton Ave., Mount Vernon, New York.

● Associated Technical Services, Inc. announces the publication of a new and angotri bibliographic tool—the 1963 *Science, Technology and General Dictionary Catalogue*. This well-indexed catalogue serves as a reference to and source of hundreds of currently available technical dictionaries in 35 languages from all over the world. The catalogue is 35 cents. Payment in coins or stamps is acceptable. Write Associated Technical Services, Inc., Dictionary and Book Division, 855 Bloomfield Ave., Glen Ridge, New Jersey.

● The August issue of the *Gas-Chrom Newsletter* (available from Applied Science Laboratories, Inc., State College, Pennsylvania) describes a method for modifying conventional diatomaceous earth supports which can then be used as adsorbents for gas-solid chromatography.

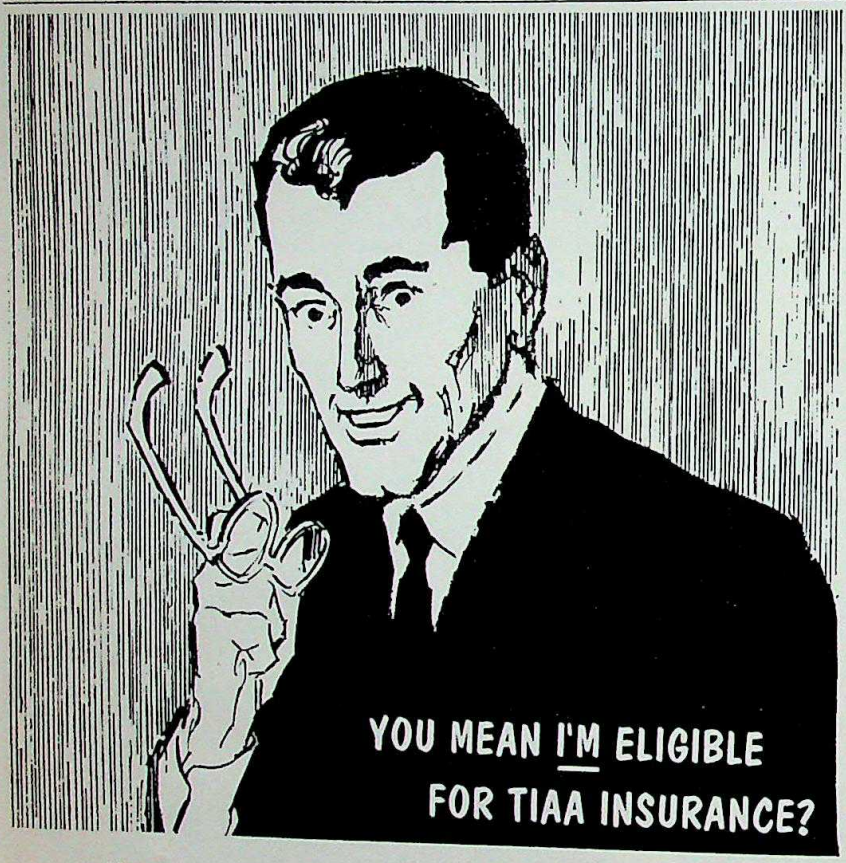
● Arthur H. Thomas Co., P.O. Box 779, Philadelphia 5, Pennsylvania is now distributing Vol. 1, No. 3 of their bulletin *Scientific Apparatus*. The 20-page bulletin illustrates and describes important new Thomas developments and current offerings of manufacturers for whom they are distributors.

● (Order the following from the Superintendent of Documents, U. S. Government Printing Office, Washington 24, D. C.) *Calculations of the Potential and Effective Diffusion Constant in a Polyelectrolyte Solution*, by Sam R. Coriell and Julius L. Jackson; National Bureau of Standards Technical Note 192; June 28, 1963; 29 pages; 25 cents. *Refractive Indices and Densities of Aqueous Solutions of Invert Sugar*, by Carl F. Snyder and Albert T. Hattenburg, National Bureau of Standards Monograph 64; June 7, 1963; 6 pages; 15 cents. *Radiobiological Dosimetry: Recommendations of International Commission on Radiological Units and Measurements*, National Bureau of Standards Handbook 88; April 30, 1963; 16 pages; 25 cents.

● An 8-page folder available from John P. Mickel Associates, Inc., 158 S. Rochester Rd., Clawson, Michigan, describes: gases pure to one part per million or less; gas chromatographs sensitive to one part per million or less; gas purifiers that clean to one part per ten million; sample crushers that make possible the analysis of trapped gases such as bubbles in glass as small as two millionths of a milliliter; a 48-hr service on gas analysis sensitive to one part per million or less.

● The new, condensed Welch "Duo-Seal" Vacuum Pump Catalog includes illustrations, descriptions, performance curves, specifications, and prices of their complete line of vacuum pumps. It shows single-stage and two-stage, oil-sealed, rotary pumps; combination, mechanical-diffusion pumps, and their new, ultrahigh vacuum, turbo-molecular pumping unit. The complete Welch line of pumps cover a range of capacities from 21 to 8400 liters per minute (air) and ultimate pressures from 2 × 10 mm Hg (torr) down to 1 × 10 mm Hg (torr) or better. Catalog will be sent on request to The Welch Scientific Co., 1515 Sedgwick St., Chicago, Illinois 60610.

(*Continued on page 881A*)



The news about the very low net cost of TIAA life insurance is sometimes slow in getting to new college staff members—TIAA doesn't have soliciting agents.

But when they do hear, people who are eligible have a way of making up for lost time. The average size TIAA policy bought during 1962 was for $21,000. And more than half of the life insurance issued that year was to "satisfied customers coming back for more."

Eligibility for TIAA life insurance is open to all employees of colleges, universities, private schools, and certain other nonprofit educational or scientific institutions. If you're eligible, use the coupon below to request a copy of TIAA's new Life Insurance Guide and a personal illustration of low-cost TIAA insurance at your age.

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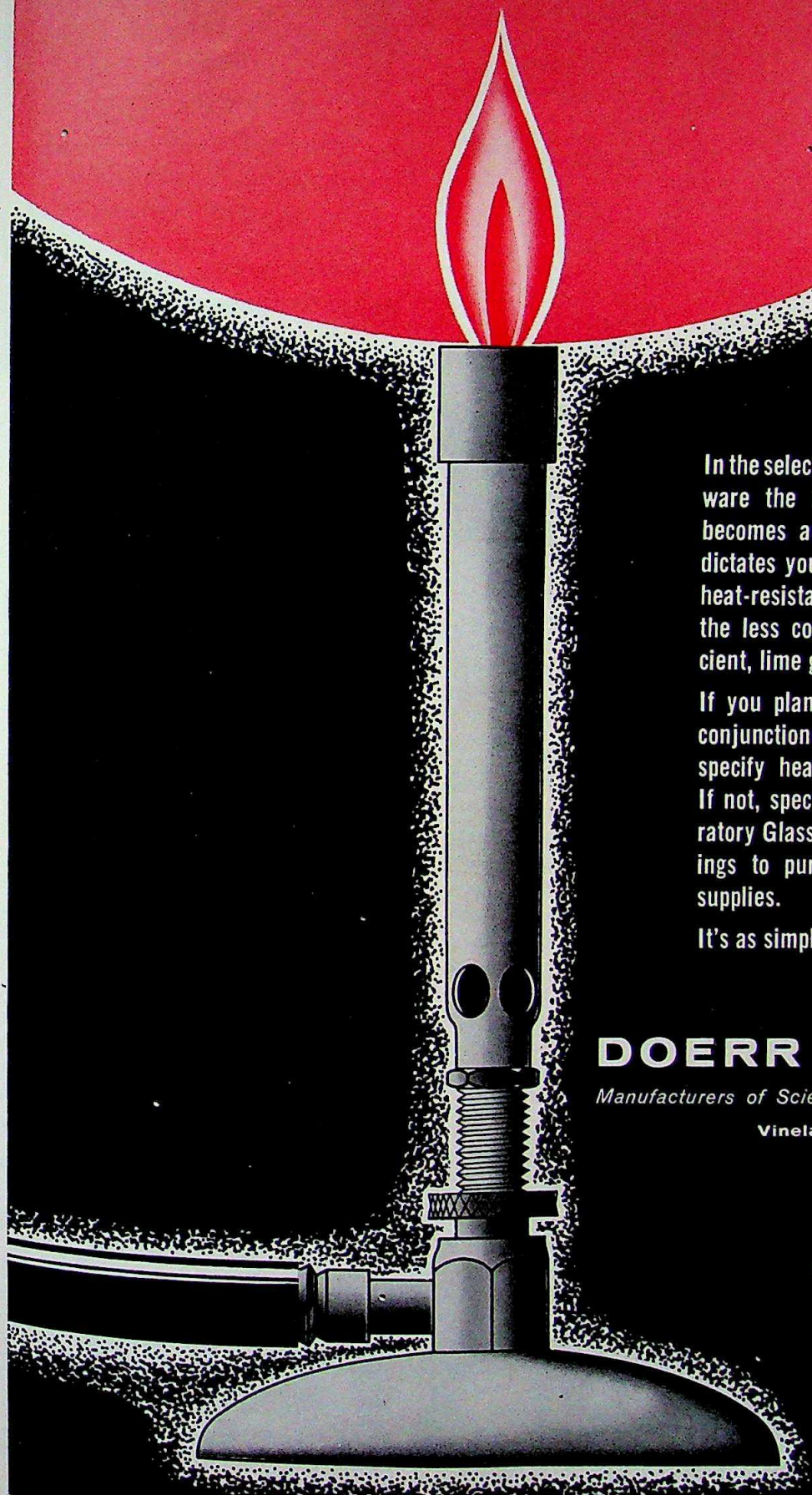

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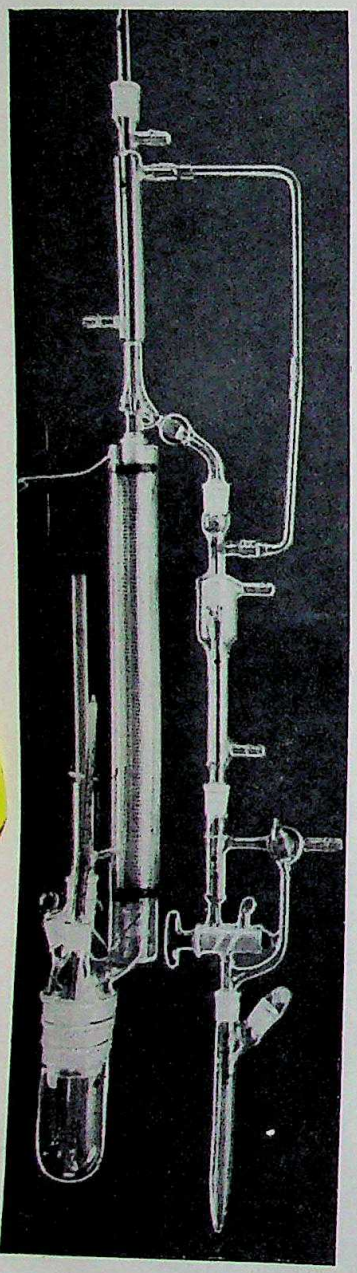
27 new items get your copy!



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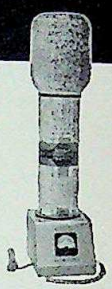

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Out of the EDITOR'S BASKET

● A new 16-page bulletin on Multichannel Analyzers is now available from Packard Instrument Co., LaGrange, Illinois. *Bulletin 1032* provides complete descriptions and specifications on Packard Models 15 and 16 400-channel analyzers. Included are descriptions of operating modes of the analyzers, with typical oscilloscope traces; an explanation of analyzer operations at various voltage/channel combinations, together with schematic diagrams; and methods of automatic programming. For a copy of *Bulletin 1032*, write Packard Instrument Co., Inc., Box 428, LaGrange, Illinois.

New Chemicals

◊ Information on "Sephandex" a cross-linked detran material as spherical beads for column packing may be obtained from Pharmacia Fine Chemicals, Inc., 501 Fifth Ave., New York 17, N. Y.

◊ Chrom-Line Labs, P.O. Box 1231, Kansas City, Missouri, offer "Molecular Sieve Flour" for work in gas chromatography.

◊ Cesium metal with the increased purity of 99.97 per cent is now available from The Dow Chemical Co., Midland, Michigan. Production process improvements have reduced maximum impurities from 0.07 per cent to 0.03, decreasing the cesium's content of other alkali metals and oxygen.

◊ A solder glass kit containing powdered glass and a liquid suspension vehicle is being marketed by Corning Glass Works, Corning, New York, as an aid to college laboratories and other high-vacuum research facilities.

◊ United States Testing Co., Inc., 1415 Park Ave., Hoboken, New Jersey announces the introduction of a new line of high purity spectographic grade chemicals to be marked under the brand name "Spectroline."

Miscellany

★ Dr. Herman Liebhafsky surveyed the fuel cell problem for his colleagues in the Summer issue of General Electric's *Research Laboratory Bulletin*. Attention was focused on the approximately 25 million being spent for research in this area and the variety of interrelated chemical engineering difficulties that are involved.

★ Are you aware of Hydroscan? The use of such a system for continuous monitoring of total water in moving solids is discussed in *CEC/Recordings*, second quarter 1963.

★ Applications will be accepted through January 3, 1964, for National Science Foundation Graduate Fellowships for advanced study in the sciences. To be eligible for Graduate Fellowships, applicants must be citizens or nationals of the United States and have demonstrated ability and special aptitude for advanced training in the sciences. Fellows will be selected on the basis of ability as attested by letters of recommendation, academic records, scores achieved in the Graduate Record Examinations, and other appropriate evidence of potential ability for scientific study or work. Application material for National Science Foundation Graduate Fellowships may be obtained from the Fellowship Office, National Academy of Sciences National Research Council, 2101 Constitution Ave., N.W., Washington, D. C. 20418. Awards will be announced on March 15, 1964.

★ An Advanced Research Conference will highlight a week, February 3–7, 1964, devoted to gas chromatography at the University of California, Los Angeles. Dr. Robert L. Pecsok, Professor of Chemistry, announces a program of distinguished chemists who will discuss "Progress in Gas Chromatography," emphasizing their own work. On the conference program for February 3 and 4 are: Dr. J. H. Purnell, University of Cambridge, England; Dr. Charles N. Reilley, University of North Carolina, Chapel Hill; Dr. Paul Boyer, University of California, Los Angeles; Dr. James C. Sternberg, Beck-

(*Continued on page A882*)

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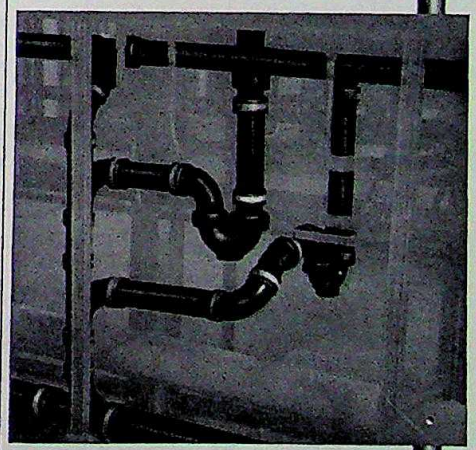

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man Instruments, Inc., Fullerton; and Dr. Evan C. Horning, Baylor University, Houston.

The sixth short course in "Fundamental Principles of Gas Chromatography" will be held February 5–7. This intensive three day course is presented in response to many requests from industry and is an up-dated version of the very successful previous courses. It is aimed primarily to instruct personnel from industry, although it may be equally valuable to persons in academic or government laboratories. The approach will be non-mathematical, stressing theory only to the extent necessary to understand the practical aspects and to obtain optimum results.

The two programs are independent and both are jointly sponsored by the Department of Chemistry, Engineering Extension, and Physical Sciences Extension, with Dr. Pecsok as the Coordinator. Fee for the two day Conference will be $25, and for the three day Course $100. Additional information and application blanks may be obtained by phoning or writing to H. L. Tallman, Physical Sciences Extension, Room 6532 Engineering Building, University of California, Los Angeles 24, California (272-8911, extension 3121).

Attendance at both programs will be limited with selection on a first come first served basis.

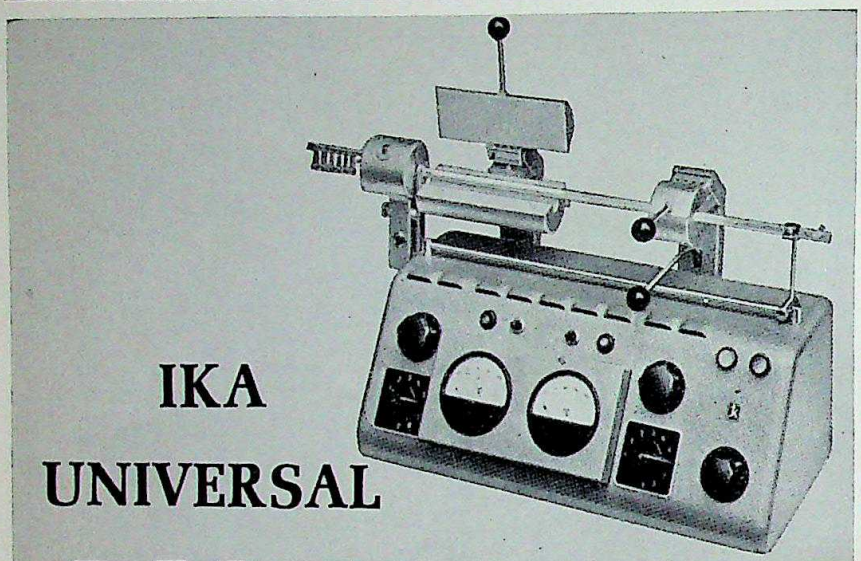
★ You can now buy a top-quality pocket slide rule at the price you would expect to pay for ball-point pen. This all plastic slide rule has the same kind of engraved scales and tongue and groove construction found on more expensive slide rules and nine different scales, C, D, CI, B, A, K, S, T, and L. For additional information contact Dyna-Slide Co., 600 S. Michigan Ave., Chicago 5, Illinois.

★ The National Science Foundation announces the next series of closing dates for receipt of proposals for Basic Research in Life Sciences, January 15, 1964 and Renovation and Construction of Graduate-level Research Facilities, December 1, 1964. Proposals received prior to these dates will be reviewed and notification of the Foundation's action will be made within four months. Inquiries or proposals requesting support should be addressed to the National Science Foundation, Washington, D. C. 20550.

★ The National Science Foundation will again offer fellowships for Secondary School Teachers of Science and Mathematics to several hundred teachers, for summer study beginning in 1964. The fellowships will be awarded competitively on the basis of the candidate's ability to carry out an individually planned graduate level program in the mathematical, physical, or biological sciences.

An applicant for a Summer Fellowship for Secondary School Teachers must be (1) a citizen or national of the United States, (2) a science or mathematics teacher in a secondary school, with at least three year's experience in that capacity, and (3) a holder of a baccalaureate degree or its equivalent. Information and application materials may be secured by addressing a request to NSF Secondary School Teacher Fellowships, American Association for the Advancement of Science, 1515 Massachusetts Ave., N.W., Washington, D. C. 2005. Completed applications must be received by the Association by January 3, 1964.

★ Applications for the NSF Postdoctoral Fellowship Program will be accepted through December 16, 1963. To be eligible for Postdoctoral Fellowships, applicants must (1) be citizens or nationals of the United States, (2) possess special aptitude for advanced training, and (3) have obtained the doctoral degree prior to beginning tenure or have the equivalent education and experience. Postdoctoral Fellows will be selected on the basis of ability as evidenced by letters of recommendation and other appropriate evidences of scientific competence. Application materials may be obtained by writing to the Fellowship Office, National Academy of Sciences, National Research Council, 2101 Constitution Ave., N.W., Washington, D. C. 20418. Completed materials must be received not later than December 16, 1963.



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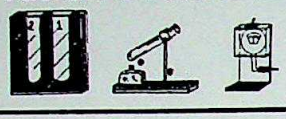

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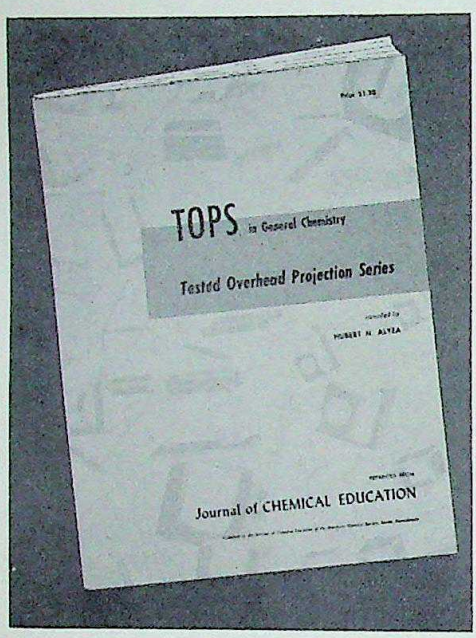
Princeton University



Insistent demands for copies of the instalments already published in this series have prompted the publication of this initial reprint. It contains all the instalments published in the *Journal of Chemical Education* from January 1962 through August 1963, thus including the articles on the construction of the inexpensive overhead projector and the basic kit of simplified TOPS devices.

Because "Tops in Chemistry" will take several years for complete publication, Dr. Alyea has prepared a special section, exclusively for this booklet, which he calls, "The Top Ten Tops." This lists the ten experiments best suited for projection in each of the 24 topics in his book, "Tested Demonstrations."* By referring to this book and using the data given in "The Top Ten Tops," the teacher will be able to work out his own 240 projection experiments. Eventually these will be described in greater detail in the forthcoming instalments of the TOPS series in the *Journal of Chemical Education*.

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     c) Reactions with Oxygen Gas
     d) Some oxidations
     e) Ozone
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     b) Preparation of Hydrogen
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Compiled by
HUBERT N. ALYEA
Princeton University

2. PHYSICAL PROPERTIES OF WATER

Aqueous Tension *(Continued)*

Dem. 103—Deliquescence, Using a Balance

To show: The increase in weight of $MgCl_2$ exposed to moist air.

Materials: See-saw balance (SD-20-S); $MgCl_2$, filter paper, plastic cover $5 \times 2^1/_2 \times 1^1/_2$.

Procedure: Project see-saw balance SD-20-S. Fold filter paper into a $^3/_4$-in. square, soak thoroughly in saturated $MgCl_2$-aq., and place on the left pan. Place a similar, dry paper in the right pan. Add water dropwise to the latter, until the balance *just* dips. Cover balance with plastic case.

Observation: Within 30 min, the balance tips to the side where the $MgCl_2$ has absorbed moisture from the air. (Noerdin)

SD-20—A Variety of Balances

The balances pictured below serve a variety of purposes. Balance SD-20-K is a Knife-edge balance useful for accurate measurements. Balance SD-20-S is a See-saw balance useful for showing which of two objects is definitely heavier. Balance SD-20-V is a Visible-scale balance enabling the student to see the actual weights on the screen.

Construction of balances. Balance SD-20-K. Purchase from Edmund Scientific Co., Barrington, New Jersey Catalog No. 0000 Price $15 includes balance and set of weights from 10 g down to 0.1 g. Unscrew metal base and discard. Replace with a plastic box-like base, as shown in the Figure.

Balance SD-20-S. Two nails, points upwards, are set in the plastic base, as shown in the Figure. The see-saw teeters on two small conical holes in which the nail-points rest. The left pan can located in two positions; the right pan can slide along the arm to counterbalance objects placed in the left pan. The keel is added to give stability and strengthen the see-saw. A plastic cover placed over the see-saw protects it against air-currents. (Noerdin)

Balance SD-20-V. This is like SD-20-S but with a clear plastic keel along which two weights can be moved, set in notches. It is less sensitive than SD-20-S but enables the student to read what weights are on the pan. Of course the object and weights must be placed as centrally on the pan as possible.

3. CHEMICAL REACTIONS OF WATER

Dem. 104—Deliquescence and Efflorescence

To show: Change in weight of substances gaining and losing moisture from the air.

Materials: See-saw balance SD-19-S; dry P_2O_5, dry $Na_2HPO_4.7H_2O$, plastic cover $5 \times 2^1/_2 \times 1^1/_2$, filter paper.

Procedure: Project balance. Place pile of P_2O_5 on a $^3/_4$-inch square of filter paper on the left pan, and the $Na_2HPO_4.7H_2O$ on a similar paper on the right pan, to extremely small overweight. Cover with plastic case.

Observations: Balance trips in a few minutes, depending on how closely balanced the two pans are. The P_2O_5 deliquesces and gains weight, the $Na_2HPO_4.7H_2O$ effloresces and loses water and weight. (Noerdin)

Dem. 105—Dehydration of $CuSO_4.5H_2O$

To show: The addition of water to $CuSO_4$, and removal of water from $CuSO_4.5H_2O$

Materials: $CuSO_4.5H_2O$, conc. H_2SO_4, methyl alcohol, H-3.

Procedure: Place equal quantities of $CuSO_4.5H_2O$ (blue vitriol) in 3 culture tubes. Add water, conc. H_2SO_4, and a quarter-tubefull of water to one, of conc. H_2SO_4 to the middle one, and of methanol to the other. Stir.

Observations: The aqueous solution is blue due to hydrated cupric ion. In concentrated H_2SO_4 anhydrous $CuSO_4$ is formed and falls as a powder to the bottom of the tube; the supernatant liquid is colorless. With methanol the copper salt dissolves to give a clear green complex. (Noerdin)

Dem. 106—Heat of Hydration of Lime

To show: Heat evolved when unslaked lime (CaO) is treated with water (slaked).

Method 1.

Materials: Fresh lumps of CaO, iodine flakes, H-4 Grand Canyon, medicine dropper.

Procedure: (*a*) Fill coke cap with lumps of CaO, place on H-4 and project. Add a few drops of water to the CaO. (*b*) Repeat, but this time place a few flakes of iodine in the cap, and rest this on a pile of smaller, fresh, lumps of CaO. Add 1 or 2 ml of water to the lime.

Observations: (*a*) The heat of hydration of the CaO is sufficient to generate a cloud of steam, visible on the screen. The lumps of CaO are seen to crumble. (*b*) Heat sufficient to sublime the iodine (over 180°C.) is generated, and violet clouds fill the screen.

(*Chris Kato, Lillian Munson, Randy Kay, Lakeside Summer School, Seattle, Washington*)

Method 2.

Materials: Wide mouth 2-oz glass bottle, M°, fresh CaO. (CARE: Do not use plastic box).

Procedure: Place gas thermometer bulb inside of the glass bottle, and half-fill with lumps of CaO. Project. Add a few ml of water. (CARE: Violent evolution of steam).

Observations: There is a dramatic rise in temperature.

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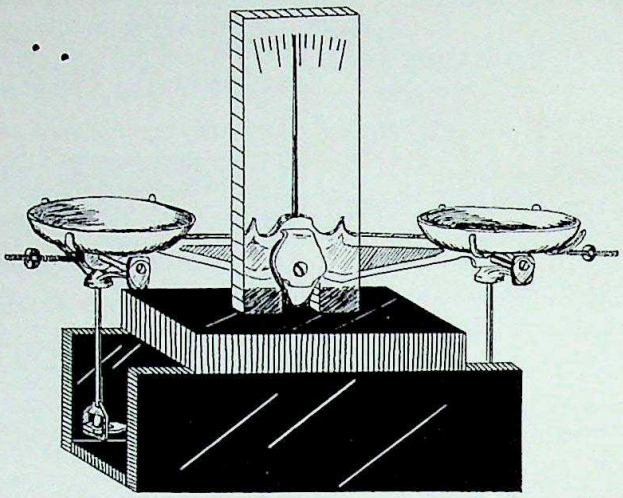
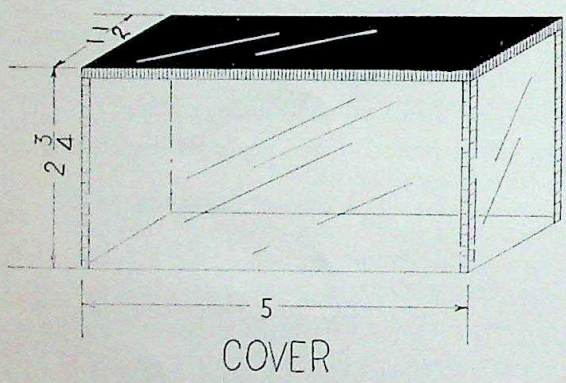
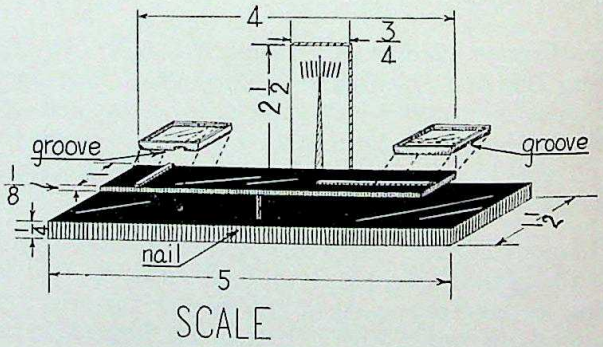
BALANCES

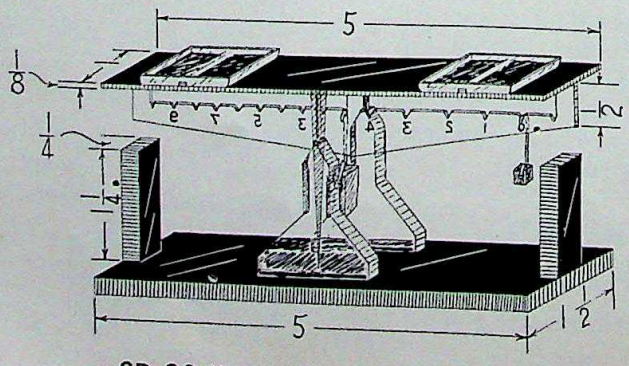


SD-20-V. Visible-scale Balance





SD-20-S. See-saw Balance



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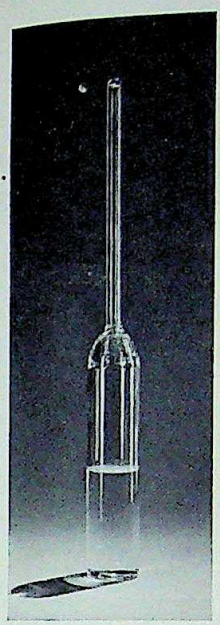

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Thoughts to buy tape by

There is a new magnetic tape. Intended for those who record sound for a living instead of just for fun, it is now coming into stock at electronics supply houses. These dealers, however, consider it none of their business whether the tape is needed for fun, profit, or the general betterment of the human race.

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2. The support is not the super-strength kind but cellulose triacetate, treated to make it stronger than triacetate has any business being. Amateur recordists generally don't realize when they buy super-strength that the low-tension equipment used in the home never requires it, though it costs something in audio uniformity and money. Professionals with their high-tension equipment, on the other hand, have long known that in case of trouble, a clean break is instantly apparent, remediable, and preferable to the treacherous stretch—over 70% before breaking—of the super-strength stuff. (Our treated triacetate stretches no more than 0.5%. We trademark it DUROL Base.)

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Radiometry of the epidermis

Policemen often moonlight. Many male schoolteachers moonlight. Work by the light of the moon to supplement one's income can be honorable, stimulating, and even necessary. When an astronomer (whose professional concerns encompass moonlight) wants to moonlight, he acquires some KODAK IRTRAN 4 Optical Material from Apparatus and Optical Division, Eastman Kodak Company, Rochester 4, N. Y. and fabricates it into a small converging lens. This transmits infrared from 1 to 20μ, a band wherein falls nearly all the energy emitted by sources around 300°K. Knowing that the human epidermis is normally a 310°K emitter, he builds the lens into a portable instrument for measuring temperature variation over small epidermal areas without actual contact and the error so introduced. He arranges for the lens to image a small area on a thermistor in a bridge circuit with microammeter. The lens makes the response independent of exact distance.

After permitting use of this instrument in clinical practice for several months, the moonlighting astronomer sounds like this:

> A female who had Raynaud's disease was scanned 5 days after 2 fingers had been amputated to the first joint. At the site of amputation the indicated temperature was lower than 2 cm back from the end of the wound. The surgeon wouldn't use a skin thermometer for fear of causing an infection in the open wound.
>
> A female presented herself with a small mass at the outer quadrant of the right breast; palpable with difficulty. It showed a 0.7°F rise in the area. She was hospitalized and a biopsy performed. An adenocarcinoma was found and removed.
>
> An elderly male with a deformed, ulcerated lesion of the right ear cartilage was examined. An 0.5°F increase over the involved area was noted. It was resected and a basal cell carcinoma was found.
>
> A female came in with psoriasis which gave rises of about 1°F over the involved areas. It was inflamed. It is notable that temperature elevations are not obtained over static cases of psoriasis.
>
> A 17-year-old female with a soft mass in the left breast presented herself. The reading was 0.5°F cooler than the surrounding tissue. One week later surgery showed that it was benign.
>
> A male was burned on the right leg. The leg was bandaged. On the third day an elevation in body temperature was noted, suggesting an infection. On scanning the bandage a reading at the knee showed a 2°F rise. On removal of the bandage the infection site was verified.

The only way currently to learn anything further about this line of development is to inquire of The Dudley Observatory (Chartered 1852), 140 South Lake Avenue, Albany, N. Y.

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a Chem Ed feature

CHEMICAL PROJECTS

Research Ideas for Young Chemists

Compiled by **JAY A. YOUNG,** King's College, Wilkes-Barre, Penna.
JOHN K. TAYLOR, National Bureau of Standards, Washington, D. C.

An Inexpensive Coulometer for Titrations with Externally Generated Reagents

See HEAD, W. F., JR., AND MARSH, M. M., *J. Chem. Educ.*, **38**, 361 (1961).

The products formed when a solution of sodium sulfate is electrolyzed are sulfuric acid and sodium hydroxide. A buret constructed in the form of an inverted "T" is fitted with two platinum electrodes, one in each arm of the "T." As a solution of sodium sulfate is allowed to run out of the buret during electrolysis, acid will run out of one arm, and base from the other. The total amount of acid, or base, formed during electrolysis is conveniently measured by a coulometer, for which a wiring diagram and constructional details are described.

Hence, by collecting either the electrolytically formed acid, or the base, in a flask containing base, or acid (the unwanted electrolysis product is discarded), and a suitable indicator, a titration can be performed. The coulometer is turned off when the indicator changes color, and the amount of acid or base generated and therefore collected in the titrating flask is noted from a dial reading on the coulometer.

By selecting other electrolytes other titrants can be electrolytically generated. For example, iodine from a solution of potassium iodide, lithium methoxide from a solution of lithium chloride in methyl alcohol are suggested in the article.

Question:

Construct the coulometer and special buret. Select a problem from another project in this series which requires a titration as part of the procedure for the solution of the problem, and perform the necessary titration coulometrically.

A Thermobalance for Student Experiments

See BOTTEI, R. S., AND GERACE, P. L., *J. Chem. Educ.*, **38**, 568 (1961).

Many substances lose weight when heated, either by partial or complete decomposition into gaseous products or by reaction with the air to form gaseous products. In thermogravimetric analysis, a substance is slowly heated from room temperature (usually) to higher temperatures of about 300°C, or even higher, while being continuously weighed. A graph showing the weight of the substance as a function of temperature can be used to interpret the reactions which occur when the substance is heated.

For example, the graph for copper sulfate pentahydrate shows more than one break, indicating that the water is driven from this salt in steps; that is, not all five water molecules are held with equal strength.

The article describes the modification of an ordinary analytical balance so that it can be used for thermogravimetric analysis. Although the authors used a magnetically damped balance for this modification, this feature is not essential. Also, it is not necessary to provide a nitrogen atmosphere for the furnace used in the heating. Instead of the Temco input controller, a manually operated rheostat or autotransformer could be used, or see M. M. MARKOWITZ, ET AL., J. CHEM. EDUC., **38**, 96 (1961) for a simple motor driven variable transformer. Another type of balance, using a strain gauge as the sensitive element, is described by W. W. WENDLANDT, J. CHEM. EDUC., **38**, 566 (1961).

Question:

Select one or more substances, or mixtures of substances, which you think will change weight when heated and determine the weight loss curve by thermogravimetric analysis. Interpret the curve you obtain, and confirm your ideas concerning the chemical changes which take place by further laboratory studies.

A Simplified Isoteniscope

See STEINBACH, O. F., AND DEVOR, A. W., *J. Chem. Educ.*, **22**, 288 (1945); *ibid*, **22**, 496 (1945).

The isoteniscope is a convenient instrument for the measurement of vapor pressures of liquids over an extended temperature range. The apparatus described in the first reference is a simplified design that could produce vapor pressure measurements of a research quality.

Essentially the apparatus consists of a boiling flask containing a thermometer and an outlet side arm which is provided with a U-tube trap all immersed in a water bath. This vessel is connected to a manometer, a ballast bottle, and a water aspirator pump to vary the pressure of the system. The water bath is heated and the pressure at which ebullition just ceases is measured as the vapor pressure of the liquid at the temperature indicated by the thermometer. The only complicated part of the apparatus is the series of bulbs constituting a trap and these could be eliminated provided the investigator was careful in his manipulation of the external pressure.

The authors discuss sources of error and illustrate the performance of the apparatus by measurements of the vapor pressures and calculations of derived heats of vaporization for five compounds. Agreement with the literature is excellent, the maximum error indicated for the heat of vaporization being 2.6 per cent. The second reference by the same authors describes a micro-modification of the apparatus that gives results of comparable or higher precision with as little as 0.5 ml of sample.

Questions:

Construct an isoteniscope as described in the references, measure the vapor pressures and calculate the heats of vaporization of representative compounds.

What improvement could you suggest that might improve the reliability of the measurements obtained with this apparatus?

Use the apparatus to measure the boiling points of a number of "pure" materials. Devise purification procedures or collaborate with others engaged in such activities and utilize your apparatus for measurements of the purification procedure.

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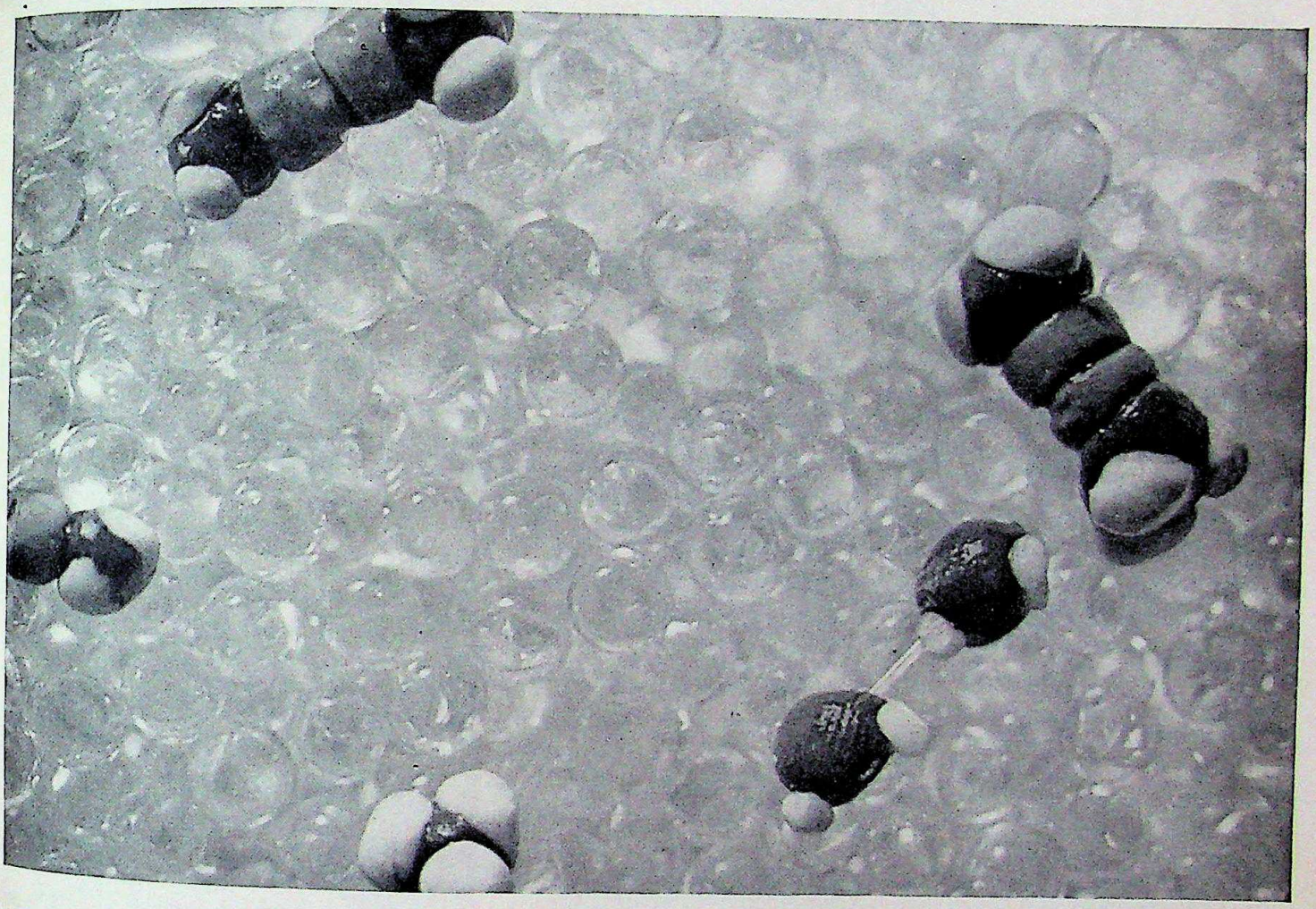
from abstract ideas . . . fundamental knowledge at Esso Research



Existence of the "cage" effect, an important concept in solution kinetics, has been confirmed directly by two Esso Research chemists, Dr. Richard K. Lyon and Mr. Donald H. Levy.

The Franck-Rabinowitch cage effect is the reverse of the diffusion controlled recombination reaction. Two highly reactive species, A and B, may react with each other so readily that the rate of reaction of an initially separate pair A and B is controlled by their diffusion towards each other. Conversely, if A and B are produced very close together (for example by the reaction $AN_2B \rightarrow N_2 + A + B$), they may react with each other before they can diffuse apart. Figuratively, as depicted in the illustration, the solvent molecules form a cage holding the reactants together. Numerous observations have been explained by invoking this "cage" effect with varying degrees of certainty.

In the experiments at Esso Research, mixtures of azomethane and d_6-azomethane were photolyzed both in gas phase and in isooctane solution. Primary steps formed CH_3 and CD_3 radicals, followed by hydrogen abstraction to methane or recombination to ethane.

Gas phase recombination occurs randomly among methyl radicals forming ethane in proportions such that $(CH_3CD_3)^2/(C_2H_6)(C_2D_6) = 4$. In solution, however, no detectable CH_3CD_3 forms, but appreciable C_2H_6 and C_2D_6 do form, experimentally proving the "cage" effect.

Separate experiments have shown "cage" effects occurring in high pressure gas phase, the diffusion coefficient being somewhat larger than in solution. These hitherto unknown "cage" effects may have a marked influence on high pressure gas phase reaction kinetics. Consideration of this effect in both high pressure gas phase and solution reactions may have great significance in determining the optimum conditions for new or existing chemical processes.

...adapted from the scientists' notes
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relative retention values

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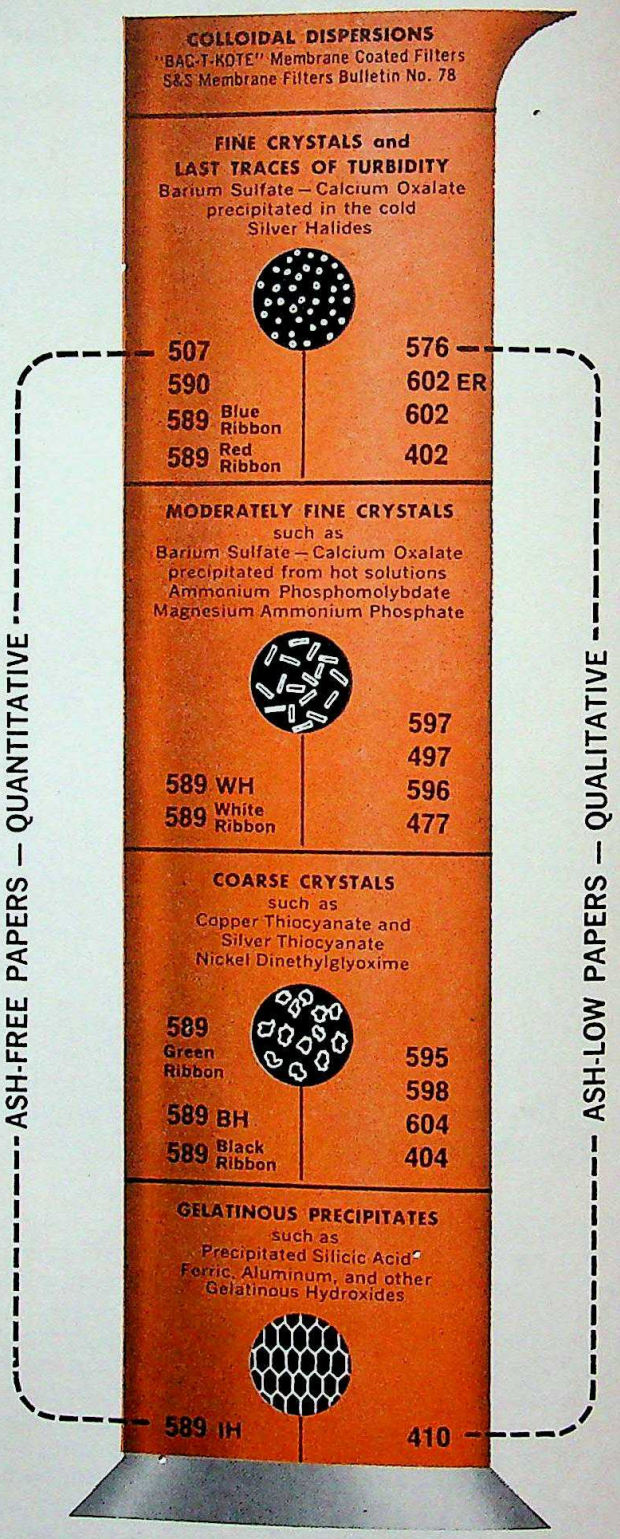

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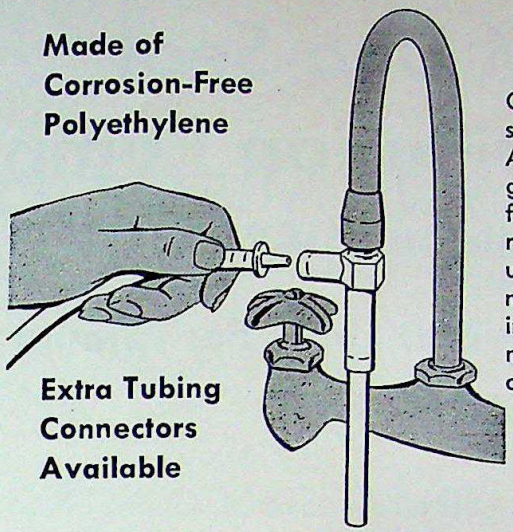

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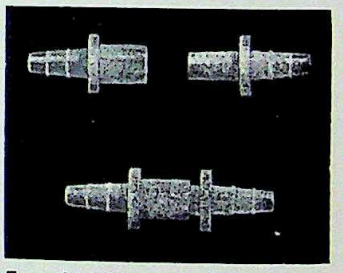

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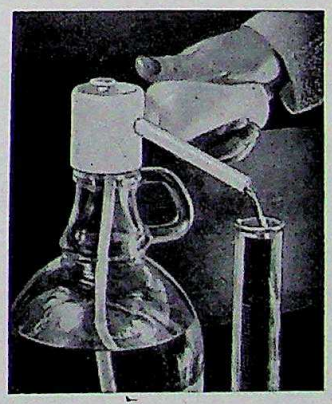

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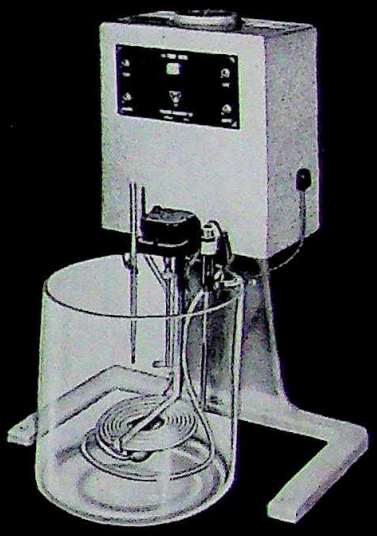

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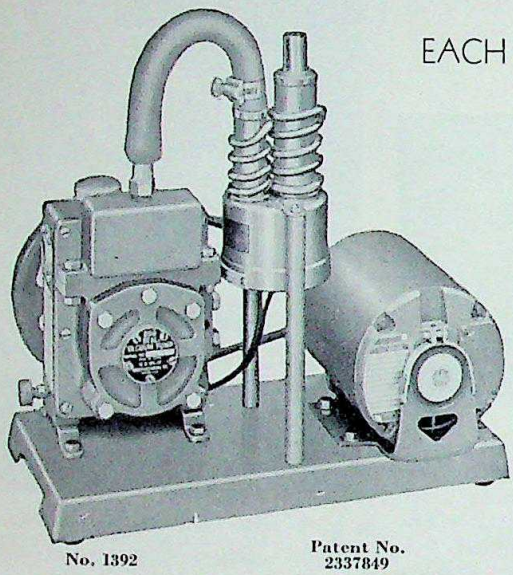

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Chem Ed

EDITORIALLY SPEAKING

Anthropomorphism is a concern that does not keep many chemistry teachers awake at night. It and its companion specter, teleology, haunt the thoughtful biologist more than his chemist counterpart. Nevertheless, total disregard of the thin philosophical ice represented by these two concepts can dump both chemistry teachers and students into the icy waters of nonsense.

Webster defines anthropomorphism as "An interpretation of what is not human or personal in terms of personal characteristics." Teleology is "The fact or character attributed to nature or natural process of being directed toward an end or shaped by a purpose." Atoms and molecules are so thoroughly inanimate that no chemist really regards them anthropomorphically or teleologically. However, the beginning student, philosophically as well as scientifically naïve, can get into real trouble if he takes seriously such a statement as "Sodium reacts with chlorine *because* the chlorine atom *eagerly* takes on the electron that the sodium atom is *so willing* to discard." We have supplied the italics, but the quote is verbatim from a general chemistry text copyrighted in 1939.

It is significant that more recent books carefully avoid this kind of statement. About the closest is such a sentence as, "The sodium atom is not 'aware' of a chlorine atom at an infinite distance." The quotation marks are the authors'. This situation seems to reflect the current attitude of chemistry teachers. A lecture can be brightened greatly by strikingly colorful or unexpected language. In context it often can hammer home a point for a puzzled student, much as any cleverly drawn analogy will. Many a truly great scientist has displayed his equal stature as teacher by such invention. Henry Eyring's "electron claustrophobia," for example, is especially rich in connotation with implications ranging from simple molecular geometry to quantum mechanics.

Anthropomorphic language is less dangerous in a lecture than in a text from which a student studies. However, even in a lecture, the speaker should be sure that audible or implied quotation marks go around his invented atomic or molecular personalities. This is easier to do when describing some thing rather than some process. Perhaps this is because chemical reactions are inherently more complicated than the simple symbolism of equations or even electron dot formulas can convey. Even quotation marks cannot give respectability to the statement, "A reaction obeys Le Chatelier's Principle because it wants to go to equilibrium."

If we return to the first quotation and examine the language, we see that this chemical baby-talk later will be regarded as nonsense by the properly educated student. He may be able to translate *eagerly* into electron affinity by stretching things, but the implication that the sodium is *so willing* (wants) to discard an electron runs into all sorts of difficulties. To tell the story correctly from an enthalpy viewpoint certainly makes justifying "want" difficult. Similarly to blanket free energy-entropy arguments or even the Born-Haber cycle by the simple word "want" would be quite a feat.

Perhaps the sly word that causes the most trouble for the novice is the word "because." Its use with beginners always needs care and amplification to avoid the easy attractiveness of a teleological connotation. The scientist may predict because he has faith in his theory, but the atoms and molecules are not scientists. Put anthropomorphically, the atoms have taken neither Chemistry 101 nor Chemistry 999. If the student is helped to realize clearly that "because" really means a correlation between information about structure and properties, the professor has done his job. Anything short of that is poor teaching. The next generation of educated men and women deserves better.

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Henry Eyring and **R. P. Marchi**
University of Utah
Salt Lake City

Significant Structure Theory of Liquids

One of the most elusive properties of nature has been a complete and consistent theory of liquids. Since the formal development of statistical mechanics some thirty years ago, there have been two main approaches to a liquid theory. There is the formal or fundamentalist approach pioneered by Mayer and Kirkwood among others and currently being widely pursued. An alternate method of attack is the model approach. In this method one visualizes a physical picture of a liquid, translates the picture into a mathematical equation, i.e., a partition function, and then computes the thermodynamic and mechanical properties of the liquid. If the model is reasonable and the calculated results agree with the experimentally determined values with sufficient faithfulness, then one assumes that the model is an adequate description of the liquid.

The formal approach provides the aesthetic pleasure of initial rigor, but at some stage during its development, up to the present at any rate, approximations must be introduced either in the form of simplified mathematics or oversimplified intermolecular potentials. In time such difficulties may be overcome. When this does happen, it will constitute a noteworthy advance.

The model approach has several immediate advantages. First of all it gives a clear visual picture of a liquid and thus provides a physical explanation for a variety of phenomena. Second, the mathematical manipulations are greatly simplified, thus reducing the elapsed time between initial interest in the value of some particular property of a specific liquid and a knowledge of the value of this property.

Naïvely, one might say that the choice between the mathematical and model approaches reduces to a choice of the time for making one's approximations. In the model approach the approximations are made at the beginning; in the formal approach they are made at the end.

The theory of liquids to be presented in this paper is a model approach and is analogous to the models customarily used for solids and gases.

We next catalog some of the known properties of the liquid state. As the temperature of a solid is increased, the substance suddenly melts to form a liquid. With a further rise, the density decreases until finally the liquid and vapor phases merge into one fluid-like substance at the critical point. This would indicate that a description of a liquid should reduce to a description of a solid or gas at the respective limits. From X-ray scattering experiments on liquids such as argon (*1*) we gain information of a more detailed nature. As the temperature of a solid increases, the coordination number of nearest neighbors, decreases from 12 in the solid to 10 or 11 in the liquid at the melting point. With rising temperature the coordination number, z, steadily decreases to approximately 4 at about five degrees below the critical temperature and then rises to 6 at the critical point. While the coordination number is decreasing to 4, the distance between nearest neighbors remains almost constant (3.8 Å for argon). Then as z rises to 6 the distance between neighbors increases (to 4.5 Å). Furthermore, the X-ray data indicates that those molecules immediately surrounding a given molecule (i.e., its nearest neighbors) are arranged in an orderly manner. The second and third nearest neighbors are arranged in a somewhat random fashion and beyond that chaos reigns. To say this in another way, a liquid possesses short range order, but a total lack of a long range order.

Excess Volume—Fluidized Vacancies

Now may we reconcile the fact that as the temperature increases the volume increases, yet the average distance between molecules remains fairly constant? A simple way of explaining this is to imagine that some of the molecules are replaced by vacancies. For example, argon expands 12% upon melting. This corresponds to removing about every eighth molecule. This would have two desirable effects. First, it would increase the volume simply by increasing the number of sites at the same time keeping the intermolecular distance more or less constant. And second, when two or more molecules share a vacancy, the lattice structure or orderly arrangement is destroyed so that we no longer have long range order.

Since the introduction of vacancies into a liquid seems to be a simple and satisfactory way of accounting for expansion, constant intermolecular distance, and lack of long range order, we shall now proceed to formulate a partition function which skirts certain difficulties and yet expresses this concept.

The key to the Pandora's box of liquids lies in elucidating the use a liquid makes of the *excess volume*, $V - V_s$, where V is the molar volume of the liquid and V_s is the molar volume of the solid. The liquid apparently utilizes this excess volume in two ways. First of all, if a molecule is rambunctious enough, that is to say if it has sufficient kinetic energy, it will take possession of some of this excess volume by pushing the neighboring molecules out of the way. By doing this it will gain entropy, or speaking in terms of a partition function, it will gain a degeneracy factor. The second use the liquid makes of the excess volume is to allow the molecule to possess translational degrees of freedom. Let us observe some particular molecule in the liquid. At some particular time it will be completely surrounded by other molecules, and so it will be vibrating about some point in space with about the same fundamental

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vibration frequency that it would have in the solid. When it is oscillating this way, we say that it is behaving in a *solid*-like manner. It then acquires some energy (by collisions with one or more of its neighbors) and transfers this energy into one of its vibrational modes of motion. The molecule then vibrates so hard in some direction that it pushes the neighboring molecules aside and takes possession of an additional position. In this process of moving to a new position external vibrational degrees of freedom are converted into translational degree of freedom. When a liquid molecule possesses translational degrees of freedom, we say it is acting in a *gas*-like manner. One naturally asks, how are the total number of degrees of freedom to be partitioned between solid- and gas-like degrees of freedom?

Before answering this question we should make a few comments about the excess volume. There are no stationary solid-like vacancies in a liquid. Light scattering experiments rule out such inhomogeneities in density. Furthermore, it is well known that liquids superheat when they are heated in vessels so clean that bubbles do not form on the walls. Thus it is clear that pure liquids have no "holes" large enough to act as nuclei for bubble formation. Also the structure of a liquid is very unstable with molecules rapidly shifting their position. Due to this rapid and irregular motion of the molecules, care must be exercised in speaking of a lattice or empty lattice site. Nevertheless, there is an excess volume, $V - V_s$, in the liquid, and this excess volume can be acquired by a molecule by pushing out its competitors. Only when a molecule has enough energy to push the neighboring molecules aside, however, does it become appropriate to speak of a hole or empty lattice site coming into existence. We call these holes *fluidized vacancies* or sometimes simply holes or vacancies. We wish to make clear, however, that these holes are very different from the locked-in almost static vacancies found in solids. The analogy between holes in a liquid and positions in an electron sea is very good. It is immaterial whether we think of molecules or electrons moving in one direction or holes or positrons moving in the other. Now certainly a hole by itself has no properties; but when a hole is surrounded by molecules, it becomes convenient to think of the hole as possessing properties. By moving into the hole, the surrounding molecules confer gas-like properties on the hole. It is simply a question of convenience whether we speak of the molecules possessing translational degrees of freedom or of the holes behaving as gas-like molecules; both descriptions refer to the same phenomenon. Likewise the term solid-like molecules does not imply that there are microcrystalline regions in the liquid. We simply mean that for short periods of time the motion of a molecule will be oscillatory. During other periods of time the motion of a molecule is translational. It reduces to a question of semantics whether we refer to these motions as solid- and gas-like or vibrational and translational.

Returning to the division of the total number of degrees of freedom, we assume that the excess in volume between the solid and liquid, to a sufficient degree of approximation, can be measured in terms of holes of molecular size. In one mole of liquid there are $(V - V_s)/V_s$ moles of vacancies per mole of molecules. The fraction of occupied positions adjacent to a vacancy is, assuming complete randomness, V_s/V. Now as we said before, a hole surrounded by vacancies has no properties; it is the molecules around a hole which confer properties on the vacancy. Thus if we multiply the number of holes, $(V - V_s)/V_s$, by the probability of molecules occupying positions around the hole, V_s/V, we obtain $(V - V_s)/V$ for the fraction of vacancies endowed with gas-like properties. The remaining fraction of a mole, V_s/V, may be thought of as associated with solid-like molecules.

Accordingly, the heat capacity at constant volume, C_v, of a mole of argon should be given closely by the sum of the contributions from V_s/V moles of solid and $(V - V_s)/V$ moles of gas. Thus:

$$C_v = 6 \cdot \frac{V_s}{V} + 3 \cdot \frac{V - V_s}{V} \qquad (1)$$

This expression was first suggested by Walter and Eyring (*2*). Its validity is tested in Figure 1. The results are sufficiently encouraging to cause us to develop the fluidized vacancy theory.

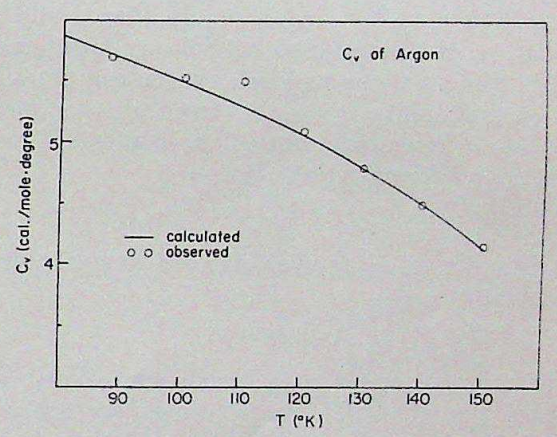

Figure 1. Heat capacity at constant volume for liquid argon. The solid curve represents equation (1), and the circles represent the experimental data.

The concept of fluidized vacancies has another advantage: it explains quite nicely the law of rectilinear diameters. This law states that the average density of a liquid and its vapor is nearly independent of temperature decreasing slowly in linear fashion as the temperature increases from the melting to the critical point. If a molecule is transferred from the liquid to the vapor without displacing the neighbors, i.e., leaving a vacancy, all bonds to neighbors are broken. In ordinary vaporization only half this energy is required since again all bonds to its neighbors are broken, but each bond joins two molecules and therefore only half the energy of a bond should be charged against each molecule. Thus the energy to make a vacancy just equals the heat of vaporization. Further, a vacancy in the liquid moves about as freely as does a molecule in the vapor. Thus the entropies of a hole and of a gas molecule should be about equal. Now since the vacancies and the vapor molecules have the same energy and entropy, it is to be expected that there will be as many vacancies per unit volume of liquid as there are molecules per unit volume of vapor. Thus the sum of the densities of the liquid and vapor will be constant except for the slight lattice expansion of the liquid causing the density of the liquid to de-

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crease slightly with temperature. Consequently, the mean density of liquid and vapor should decrease slightly with temperature (*3*).

A cardinal principle in significant structure theory is that molecular structures in the vapor are mirrored in the liquid as analogous structures made out of vacancies. Thus individual molecules translating in the vapor are mirrored as vacancies translating in the liquid. Rotating molecules are mirrored as rotating vacancies. Association of vapor molecules is matched in the liquid by association of the corresponding vacancies which translate and rotate like their molecular counterparts. This principle has been applied and verified for ordinary liquids, metals, and molten salts.

Formulation of the Partition Function

We return to the formulation of the partition function. If a molecule is to take possession of one of the fluid vacancies, it must push the neighboring molecules aside. When it does have the required energy, the additional sites become available to a molecule and there is a degeneracy factor equal to the number of sites available. The number of additional sites will be equal to the number of neighboring position, n_h, which a rambunctious molecule can occupy multiplied by the probability that the molecule has enough energy, ϵ, to move into one of these sites. Thus the number of additional sites is:

$$n_h e^{-\epsilon/kT}$$

Therefore, the total number of positions available to a given molecule is

$$1 + n_h e^{-\epsilon/kT} \tag{2}$$

If we now assume that the vibrational degrees of freedom, i.e., the solid-like molecules, are adequately represented by an Einstein oscillator (which for temperatures corresponding to the liquid region is a good approximation), we can write for the partition function, f, for a monatomic liquid such as argon the expression:

$$f = \left\{\frac{e^{E_s/RT}}{(1 - e^{-\theta/T})^3} \cdot (1 + n_h e^{-\epsilon/kT})\right\}^{N(V_s/V)} \cdot \left\{\frac{(2\pi mkT)^{3/2}}{h^3}(V - V_s)\right\}^{N(V-V_s)/V} \cdot \left\{\left(\frac{N(V - V_s)}{V}\right)!\right\}^{-1} \tag{3}$$

The first set of brackets represents the solid-like portion of the partition function. The remaining portion is the gas-like part. In the partition function for a nonlocalized independent system the number of complexions is overcounted due to the indistinguishability of the particles. Thus we must divide by the number of particles factorial. This explains the factorial term, $[N(V - V_s)/V]!$, at the end of the equation (3). Using Sterling's approximation, $x! = (x/e)^x$, equation (3) becomes

$$f = \left\{\frac{e^{E_s/RT}}{(1 - e^{-\theta/T})^3}(1 + n_h e^{-\epsilon/RT})\right\}^{N(V_s/V)} \cdot \left\{\frac{(2\pi mkT)^{3/2}}{h^3} \cdot \frac{eV}{N}\right\}^{N(V-V_s)/V} \tag{4}$$

where θ is the Einstein characteristic temperature. Note that when $V = V_s$ the exponent of the second set of brackets goes to zero leaving the partition function of a solid since $n_h e^{-\epsilon/RT}$ also goes to zero. When V is much larger than V_s, the first set of brackets effectively becomes unity and we are left with the partition function of a gas. Accordingly, this partition function has the correct asymptotic behavior. Within the solid-like portion of the partition function the factor $e^{E_s/RT}/(1 - e^{-\theta/T})^3$ occurs. This is the Einstein partition function for the external vibrations of the atom. E_s is the sublimation energy, and so the reference energy in this theory is for the atoms in their lattice framework rather than the separated atoms.

The quantity $(1 + n_h e^{-\epsilon/RT})$ is the geometrical degeneracy factor, and it is a direct result of a molecule appropriating excess volume. Accordingly, we expect n_h to be proportional to the excess volume,

$$n_h = n(V - V_s)/V_s \tag{5}$$

while ϵ should be inversely proportional to the excess volume and directly proportional to the energy of sublimation of the solid. Thus

$$\epsilon = \frac{aE_sV_s}{V - V_s} \tag{6}$$

We next require values for the proportionality factors n and a. These may be evaluated by calculating n_h and ϵ near the melting point where the liquid still approximates a solid lattice. Thus near the melting point the fraction of the neighboring positions, Z, which are empty and therefore available for occupancy is

$$Z \cdot \left(\frac{V - V_s}{V}\right) = \left(Z\frac{V_s}{V}\right) \cdot \frac{V - V_s}{V_s} = n\frac{V - V_s}{V_s} \tag{7}$$

Hence

$$n = \frac{ZV_s}{V} = 12 \cdot \frac{1}{1.12} = 10.7 \tag{8}$$

is to be compared with the value 10.8 required to fit experimental data. These added positions should be available without extra energy to a neighboring molecule. However, in melting, the other neighbors to the position have gained the kinetic energy of melting by spreading into the vacancies. According to the virial theorem the kinetic energy of melting is half the total energy of melting, E_m. Thus at, or very near the melting point

$$\frac{aE_s \cdot V_s}{V - V_s} = \frac{n - 1}{Z} \cdot \frac{1}{2}E_m \simeq \frac{n - 1}{Z} \cdot \frac{1}{2}\frac{V - V_s}{V}E_s \tag{9}$$

Hence

$$a = \frac{n - 1}{Z} \cdot \frac{1}{2}\frac{V - V_s}{V}\frac{V - V_s}{V_s} = 0.0052 \tag{10}$$

This value for a is to be compared with the value 0.00534 which is chosen to fit experimental data. The fraction $(n - 1)/Z$ results from the fact that a molecule expanding into the vacancy acquires $1/Z$ of its kinetic energy of melting and there are only $n - 1$ molecules to compete with the molecule in question. Our model thus fixes all the parameters in liquid theory except those which are properties of the solid.

An essential point in any model of the liquid is that it explains the utilization of excess volume introduced by melting. A model which omits this explanation is either a superheated solid or chilled vapor theory and not really a liquid theory at all.

Obviously, equation (9) is only approximate, but it does give a good estimate for the value of a. The error in the value of a is due to two causes. The

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quantity $E_s (V - V_s)/V$ gives a value for the heat of fusion which is about 10% too low. On the other hand the value $^1/_2$ obtained from the virial theorem for the needed kinetic energy is undoubtedly only approximate. A molecule in the liquid state is apt to lower its potential energy as it is pushed out of the excess volume. Therefore, the factor $^1/_2$ in equation (9) should be smaller. The errors in these two factors probably about compensate each other.

The theory also leads to a radial distribution function. Knowing the molar volume of the solid and the type of packing in the solid phase, we can compute the size of the molecules. If we now arrange these molecules in the volume V in the most random way possible (in obtaining the fraction of solid- and gas-like molecules, we have assumed complete randomness), we can compute a radial distribution function. Due to the fact that the molecules are not rigid spheres, but rather are elastic molecules, and since there is a distribution of kinetic energies, the peaks of the distribution function will be smeared-out, as is observed experimentally.

Using equations (5) and (6), equation (4) can be rewritten

$$f = \left\{ \frac{e^{E_s/RT}}{(1 - e^{-\theta/T})^3} \cdot \left(1 + n \frac{V - V_s}{V_s} e^{-\frac{aE_sV_s}{RT(V-V_s)}} \right) \right\}^{N(V_s/V)} \cdot \left\{ \frac{(2\pi mkT)^{3/2}}{h^3} \cdot \frac{eV}{N} \right\}^{N(V-V_s)/V} \quad (11)$$

This is the form in which the partition function for Significant Structure theory is most frequently written. Equation (11) is for liquids composed of monatomic molecules. Naturally for systems which possess internal vibrations and rotations, the appropriate expressions must be added to the solid- and gas-like portions of the partition function.

Calculation of Thermodynamic Properties

With the basic partition function given in equation (11) we are in an excellent position to calculate thermodynamic properties from the melting point to the critical point for a wide variety of substances ranging from such near-ideal liquids as argon to nonideal systems such as water. The relation between the Helmholtz free energy, A, and the partition function is

$$A = -kT \ln f \quad (12)$$

Since we now have A as a function of V and T, we can calculate all other thermodynamic properties from

$$S = -\left(\frac{\partial A}{\partial T}\right)$$

$$E = -T^2 \left[\frac{\partial (A/T)}{\partial T}\right]_v$$

$$P = -\left(\frac{\partial A}{\partial V}\right)_T \quad (13)$$

$$C_v = T \cdot \left(\frac{\partial S}{\partial T}\right)_v = -T\left(\frac{\partial^2 A}{\partial T^2}\right)_v$$

$$\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial P}{\partial T}\right)_v \Big/ \left[V \cdot \left(\frac{\partial P}{\partial V}\right)_T\right]$$

and similar expressions for the remaining thermodynamic properties.

Inert Gases (4)

For the liquid inert gases we use the partition function given in equation (11). E_s, θ, and V_s are taken from the properties of the solid phase; n is determined from equation (8) and a is estimated from equation (10). Some of the results are summarized in Table 1. It will be noted that the calculated critical pressure is in all cases too high. Inspection of equation (11) produces a possible explanation for this. As the critical point is approached, clustering becomes important. That is, concentrations of the dimer and trimer in the vapor phase become significant and thus should be included in the partition function. These clusters have the effect of decreasing the pressure. Equation (11) only includes monomers in the gas-like portion of the partition function. Presumably, inclusion of a dimer term would improve the results.

Table 1. Calculated and Observed Thermodynamic Properties of the Liquid Noble Gases

	Ar	Kr	Xe	
T_m (°K)	(83.85)	(116.0)	(161.3)	*calc*
	83.85	116.0	161.3	*obs*
V_m (cm³ mole⁻¹)	28.90	33.11	42.30	*calc*
	28.03	34.13	42.68	*obs*
P_m (atm)	0.679	0.756	0.399	*calc*
	0.674	0.722	0.804	*obs*
ΔS_m (cal mole⁻¹ deg⁻¹)	3.263	3.456	3.415	*calc*
	3.34	3.35	3.40	*obs*
T_b (°K)	87.29	119.28	167.5	*calc*
	87.29	119.93	165.1	*obs*
V_b (cm³ mole⁻¹)	29.33	33.31	42.96	*calc*
	28.69	...	...	*obs*
ΔS_b (cal mole⁻¹ deg⁻¹)	19.04	19.27	19.43	*calc*
	17.85	17.99	18.29	*obs*
T_c (°K)	149.7	208.33	287.8	*calc*
	150.66	210.6	289.8	*obs*
V_c (cm³ mole⁻¹)	83.68	88.32	113.52	*calc*
	75.26	...	113.8	*obs*
P_c (atm)	52.93	69.68	74.89	*calc*
	48.00	54.24	58.2	*obs*

Diatomic Liquids

Significant Structure theory has been applied to a number of diatomic liquids: nitrogen (*4*), chlorine (*5*), fluorine, bromine (*6*), iodine (*6*), and also hydrogen (*7*) which requires the use of quantum statistics. The theory is presently being applied to liquid oxygen. Let us examine the application of the theory to chlorine for which the results are typical.

The unusually high entropy of fusion and the absence of transition peaks in the heat capacity curve for solid chlorine indicate that the chlorine molecule does not rotate freely in the solid state. Also the density data on liquid chlorine suggest that rotation is hindered in the liquid state. To avoid complicating the partition function by considering libration-type degrees of freedom, the six degrees of freedom in the solid-like portion of the partition function are assigned to a five degree Einstein oscillator and one internal vibration. Free rotation was assumed in the gas-like portion of the partition function. The partition function for liquid chlorine, then, is:

$$f_{Cl_2} = \left\{ \frac{e^{E_s/RT}}{(1 - e^{-\theta/T})^5} \cdot \frac{1}{(1 - e^{-h\nu/kT})} \cdot (1 + n_h e^{-aE_sV_s/RT(V_s - V)}) \right\}^{N(V_s/V)} \cdot \left\{ \frac{(2\pi mkT)^{3/2}}{h^3} \cdot \frac{eV}{N} \cdot \frac{1}{(1 - e^{-h\nu/kT})} \cdot \frac{8\pi^2 IkT}{2h^2} \right\}^{N(V-V_s)/V} \quad (14)$$

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Figures 2 and 3 compare some of the calculated and observed properties. The critical temperature is about 11% too high, the critical volume about 6% too high, and the critical pressure is too large by 38%. The results for chlorine are typical of the results obtained for many other liquids: from the melting point to the boiling point the agreement with experiment is very good; above the boiling point deviations occur so that T_c and V_c are 5–10% too high and P_c is 30–50% too large.

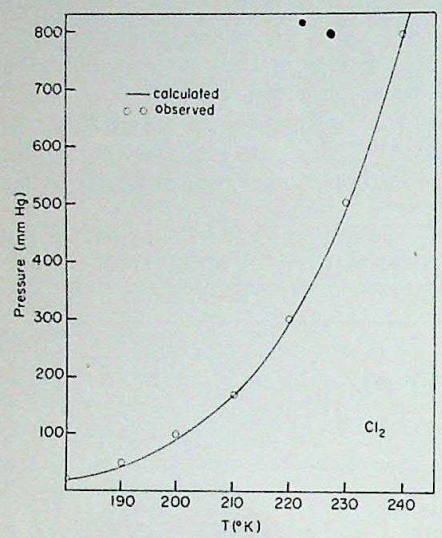

Figure 2. Vapor pressure versus temperature for liquid chlorine.

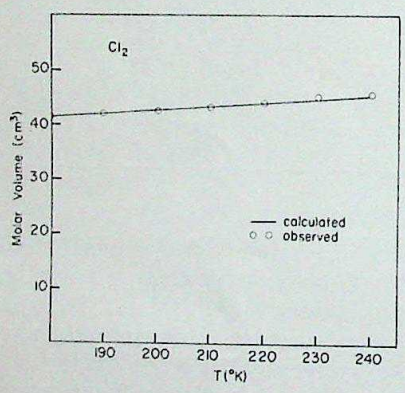

Figure 3. Molar volume versus temperature for liquid chlorine.

Organic Liquids

The theory has been applied to a number of organic liquids ranging from such simple hydrocarbons as methane, ethane, and benzene (*4*) to the halocarbons, carbon tetrachloride and carbon tetrafluoride (*8*). The experimental heat capacity curves for both CH_4 and CCl_4 indicates that the molecules rotate in the solid state. We therefore assume that they rotate in the liquid state. The partition function for liquid CH_4 or CCl_4 then is

$$f = \left\{\frac{e^{E_s/RT}}{(1-e^{-\theta/T})^3}\left(1 + n\,\frac{V-V_s}{V_s}\,e^{-aE_sV_s/RT(V-V_s)}\right)\right\}^{N(V_s/V)} \cdot \left\{\frac{(2\pi mkT)^{3/2}}{h^3}\cdot\frac{eV}{N}\right\}^{N(V-V_s)/V} \cdot \left\{\prod_{i=1}\frac{1}{(1-e^{-h\nu_i/kT}}\cdot\frac{(8\pi^2kT)^{3/2}\cdot(\pi ABC)^{1/2}}{12\cdot h^3}\right\} \quad (15)$$

A, B, and C are the principal moments of inertia and the factor 12 is the symmetry number for molecules having the configuration of a CH_4 molecule. Since the partition functions for the internal vibrations and the rotations occur in both portions of the partition function, we have factored them out for convenience. Some of the results for methane are given in Table 2.

Table 2. Calculated and Observed Thermodynamic Properties of Methane

	Calc	*Obs*[5]
T_m (°K)	(90.65)	90.65
V_m (cm³ mole⁻¹)	34.11	35.42
P_m (atm)	0.1172	0.1151
ΔS_m (cal mole⁻¹ deg⁻¹)	2.48	2.48
T_b (°K)	111.67	111.67
V_b (cm³ mole⁻¹)	36.35	37.79
P_b (atm)	0.974	1.000
ΔS_b (cal mole⁻¹ deg⁻¹)	17.40	17.51
T_c (°K)	214.0	191.04
V_c (cm³ mole⁻¹)	103.9	99.02
P_c (atm)	63.3	45.8

Molten Metals (9)

Since the conducting (outer) electrons of a metal are spead out over the positive ions, only vacancies for the ions need appear in the liquid. In general, ions are only about a third the size of atoms, therefore the vacancies are also smaller. Thus when metals melt, they expand only 3 or 4%, that is, about a third as much as a normal liquid. However, the entropy of melting is almost the same as that of a normal liquid, so it follows that n must have a value three times that of a normal liquid. In the vapor above a molten metal appreciable concentrations of the dimer species exist. Arguments similar to those used in explaining the law of rectilinear diameters lead one to conclude that the vacancies in the liquid are also paired. Due to the relatively high dimer concentration in the vapor a dimer term has been included in the gas-like portion of the partition function for molten metals.

$$= \left\{\frac{e^{E_s/RT}}{(1-e^{-\theta/T})^3}\left(1 + n\,\frac{V-V_s}{V_s}\,e^{-aE_sV_s/RT(V-V_s)}\right)\right\}^{N(V_s/V)} \cdot \left\{\left(f_1\cdot\frac{eV}{N}\right)^2 + \left(f_2\cdot\frac{eV}{N/2}\right)\right\}^{N/2/(V-V_s)/V} \quad (16)$$

where

$$f_1 = \frac{(2\pi m_1kT)^{3/2}}{h^3}$$

$$f_2 = \frac{(2\pi m_2kT)^{3/2}}{h^3}\cdot\frac{8\pi^2IkT}{2h^2}\cdot\frac{e^{D/RT}-1}{1-e^{-h\nu/kT}}$$

and m_1, m_2, I, D, and ν are the masses of the monatomic and diatomic metal atoms, the moment of inertia, the dissociation energy, and the ground state vibrational frequency of the dimer. As $T \rightarrow T_c$, the electrons are no longer smeared-out over the positive ions, and the atoms no longer behave as if they were ions. Thus the value of n must now be near to that of a normal liquid. The partition function in equation (16) has been used to calculate properties for liquid sodium, mercury, copper, and lead. Some typical results are

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given in Figure 4, which plots molar volume versus temperature for liquid mercury over a four hundred degree temperature span. At 600°K it is approximately 3% too small.

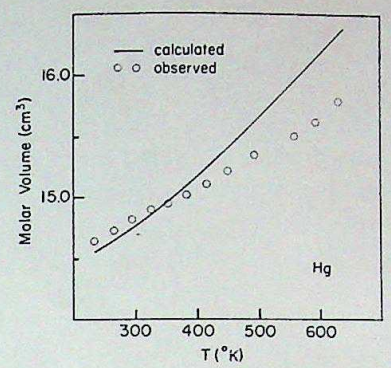

Figure 4. Molar volume versus temperature for liquid mercury.

Fused Salts (10)

The observed percentage change in volume for argon upon melting is 12%. For molten salt such as NaCl the per cent expansion is approximately twice that of argon. The entropy of melting comes from the randomness introduced by the excess volume. Since positive ions can occupy only half of the fluid vacancies while negative ions can occupy the other half, it should require twice the per cent expansion to obtain the same entropy increase for each kind of ion. This is in accord with the experimental observations. The fact that only half the excess volume provides vacancies for each kind of ion means the factor n in the degeneracy should only be about half as large for salts as it is for argon. The partition function for a mole of alkali halide molecules is

$$f = \left\{ \frac{e^{(E_s/2RT)}\,(V/V_s)^{1/3}}{(1-e^{-\theta/T})^3} \left(1 + n_h e^{(-a'E_s/n_h RT)}\,(V/V_s)^{1/3}\right) \right\}^{2N(V_s/V)} \cdot \left\{ \frac{(2\pi mkT)^{3/2}}{h^3} \cdot \frac{eV}{N} \cdot \frac{8\pi^2 IkT}{h^2} \cdot \frac{1}{(1-e^{-h\nu/kT})} \right\}^{N(V-V_s)/V} \quad (17)$$

the solid-like portion of the partition function is raised to the $2N\ V_s/V$ power because a mole of alkali halide contains $2N$ particles. The alkali metal ions and the halide ions are in the same environment so a common Einstein temperature is used for both. E_s/N is the sublimation energy per molecule. The E_s required in the partition function is the sublimation energy per ion so we must divide by two. To account for the long-range nature of the coulombic interionic potential the sublimation energy must be altered. For liquid argon (see eq. (11)) the energy falls off as $E_s\ V_s/V$, that is inversely as the volume which was what van der Waals suggested for gases long ago. This is not true for the molten salts, however, since in one of the three dimensions a Na^+ and a Cl^- cling together, and so there is expansion only in the other two directions. Therefore, the energy should decrease about as $1/V^{2/3}$; thus in the partition function we multiply E_s by $(V/V_s)^{1/3}$. The gas-like portion of the partition function is composed of molecules whose moments of inertia and ground state vibrational frequencies are assumed to be the same as for the vapor phase. A summary of the results is given in Table 3. The agreement with the observed data is good. Recent experimental work has indicated that vapors of the alkali halides are strongly associated to four and six atom complexes. Inclusion of these terms in the partition function should improve the results.

Table 3. Thermodynamic Properties of the Fused Alkali Halides

Melting-Point Properties of the Alkali Halides

		NaCl	KCl	NaBr	KBr
T_m (°K)	*calc*	1070	1023	(1023)	(1008)
	obs	1074	1049	1023	1008
V_m (cc)	*calc*	38.14	49.06	43.84	56.13
	obs	37.74	48.80	44.08	56.03
ΔS_f (eu)	*calc*	7.75	5.40	6.16	4.83
	obs	6.3	5.8	5.96	6.94

Boiling-Point Properties of the Alkali Halides

		NaCl	KCl	NaBr	KBr
T_b (°K)	*calc*	1750	1684	1671	1661
	obs	1738	1680	1665	1653
V_b (cc)	*calc*	51.15	71.20	60.15	81.81
	obs	...	...	...	...
ΔS_v (eu)	*calc*	21.55	21.63	21.02	20.89
	obs	23.5	23.1	23.2	22.4

Critical Constants of the Alkali Halides

	NaCl	KCl	NaBr	KBr
T_c (°K)	3600	3092	3364	3060
V_c (cc)	293	431	342	482
P_c (atm)	235.5	135.5	186.1	118.3

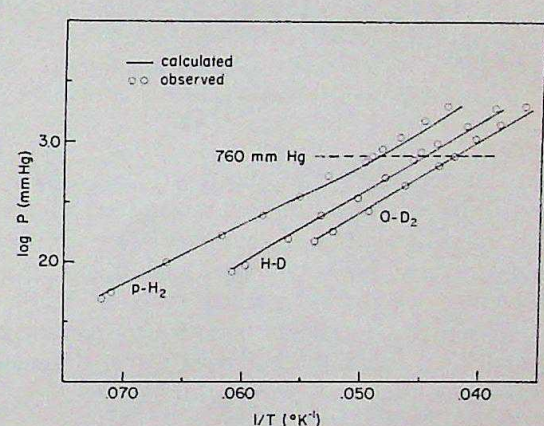

Figure 5. Vapor pressure of liquid para hydrogen, hydrogen deuteride and ortho deuterium.

Liquid Hydrogen (7)

The theory has been applied with excellent results to liquid hydrogen, deuterium, and hydrogen deuteride. It provides an interesting test for this approach to liquids since changes in the concentrations of ortho and para hydrogen cause slight changes in the thermodynamic properties. Because these liquids exist at extremely low temperatures a Debye partition function is used for the solid-like degrees of freedom and equation (7) is used for n_h. The gas-like molecules are treated as a slightly degenerate gas which obeys Bose-Einstein statistics for the cases of hydrogen and deuterium and Fermi-Dirac statistics for the

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case of hydrogen deuteride. Henderson thus obtained the following partition function

$$f = \left\{\frac{e^{E_s/RT}}{f_D}(1 + n_A e^{-aE_s V_s/RT(V-V_s)}) \cdot f_r\right\}^{N(V_s/V)} \cdot \left\{e^{(1-\ln y \pm y/2^{3/2})} \cdot f_r\right\}^{N(V-V_s)/V} \quad (18)$$

where f_D is the Debye partition, f_r is the rotational partition function and depends upon the species, and y is related to the translational partition function. The reader is referred to the original paper for more details on the partition function, since it is inherently complex. Table 4 lists some calculated and observed properties at the melting, boiling, and critical point. Figure 5 shows the vapor pressure curves versus temperature for several species.

Dense Liquids and Gases (11)

The theory as described above works very well for normal temperatures and pressures. A few simple corrections, which are natural consequences of the model, extend the useful range of the theory to very high pressures and temperatures with highly satisfactory results.

In using an Einstein oscillator in the solid-like portion of the partition function it was tacitly assumed that $l\,\theta \gg T$, where l is the vibrational quantum number. The exact partition function of a one dimensional harmonic oscillator terminating at the l-th level is given by

$$\sum_{i=0}^{l-1} e^{-i\theta/T} = \frac{1 - e^{-l\theta/T}}{1 - e^{-\theta/T}} \quad (19)$$

and l is determined by the relation $l\,\theta \simeq E_s/3R$. The usual Einstein partition function is obtained when $l\,\theta \gg T$. This condition, $l\,\theta \gg T$, however, does not hold at high temperatures for substances with a low E_s (i.e., low molecular weight substances such as argon and neon). When this condition is no longer satisfied, the one dimensional oscillator becomes a one dimensional gas with one translational degree of freedom:

$$e^{-l\theta/T}\frac{(2\pi mkT)^{1/2}}{h} \cdot \nu_f^{1/3} \quad (20)$$

where ν_f is the molar free volume in the solid. Since at high temperatures molecules act like hard spheres, ν_f may be represented by

$$\nu_f = [(V_s/N)^{1/3} - (b/4N)^{1/3}]^3 \quad (21)$$

where b is the van der Waals constant and $b/4N$ is the net molecular volume. We, therefore, replace the simple Einstein partition function in equation (11) by

$$e^{E_s/RT}\left\{\frac{1 - e^{-l\theta/T}}{1 - e^{-\theta/T}} + e^{-l\theta/T} \cdot \frac{(2\pi mkT)^{1/2}}{h} \cdot \nu_f^{1/3}\right\} \quad (22)$$

When $l\,\theta \gg T$, equation (22) reduces to the Einstein partition function in equation (11); and when $T \gg l\,\theta$, it reduces to a translational partition function.

The equation of state obtained from equation (11) modified by means of equation (22) is

$$P = \frac{RT}{V_s x^2}\left[-\sigma_1 - \sigma_2 + x \cdot \left(\frac{2\sigma_2}{2x}\right)_T + \gamma + x - 1\right] \quad (23)$$

where

$$x = V/V_s$$

and

$$\sigma_1 = E_s/RT + 3\ln\left\{\frac{1 - e^{-l\theta/T}}{1 - e^{-\theta/T}} + e^{-l\theta/T} \cdot \frac{(2\pi mkT)^{1/2}}{h} \cdot \nu_f^{1/3}\right\}$$

$$\sigma_2 = \ln\{1 + n(x-1)e^{-aE_s/RT(x-1)}\} \quad (24)$$

$$\gamma = \ln\left\{\frac{(2\pi mkT)^{3/2}}{h^3} \cdot \frac{eV}{N}\right\}$$

In addition to the quantum effect mentioned above, the pressure effect on V_s must also be considered. Thus

$$V_s = V_s(1 - \beta\Delta P) \quad (25)$$

β is the solid compressibility and ΔP is the excess pressure above a standard pressure, say the vapor pressure at the melting point. Since β is rather small, 10^{-5} to 10^{-7} atm^{-1}, equation (25) reduces to V_s if ΔP is small. For argon, as an example, the pressure effect is negligible if ΔP is less than 500 atmospheres.

From equation (23) the second virial coefficient may be determined:

$$B(T) = V_s(\gamma - \sigma_1 - \ln n) \quad (26)$$

and compared with experiment. Some results for nitrogen are shown in Figure 6. Figure 7 shows the compressibility factor, PV/RT, as a function of density for argon at 150°C. The values obtained by Kirkwood and Hirschfelder are also shown.

Table 4. Calculated and Observed Thermodynamic Properties of Liquid Hydrogen

	p-H_2	n-H_2	H-D	o-D_2	n-D_2	
T_m (°K)	(13.84)	(13.94)	(16.60)	(18.63)	(18.73)	*calc*
	13.84	13.94	16.60	18.63	18.73	*obs*
P_m (atm)	0.07388	0.07589	0.1236	0.1706	0.1724	*calc*
	0.06942	0.07085	0.1221	0.1678	0.1692	*obs*
V_m (cm³ mole⁻¹)	26.213	26.093	24.491	23.262	23.155	*calc*
	26.176	26.108	24.487	...	23.162	*obs*
ΔS_m (cal mole⁻¹ deg⁻¹)	1.932	1.936	2.048	2.198	2.210	*calc*
	2.028	...	...	2.526	...	*obs*
T_b (°K)	20.58	20.70	22.29	23.65	23.75	*calc*
	20.261	20.365	22.14	23.59	23.67	*obs*
V_b (cm³ mole⁻¹)	28.829	28.692	26.525	24.955	24.830	*calc*
	28.482	28.393	...	...	...	*obs*
ΔS_b (cal mole⁻¹ deg⁻¹)	10.553	10.564	11.868	12.741	12.737	*calc*
	10.602	...	...	12.459	...	*obs*
T_c (°K)	35.9	36.2	37.6	39.4	39.7	*calc*
	32.994	33.24	35.908	38.262	38.24	*obs*
P_c (atm)	13.6	13.8	15.5	17.1	17.3	*calc*
	12.770	12.797	14.645	16.282	16.421	*obs*
V_c (cm³ mole⁻¹)	77.7	77.3	71.5	68.3	68.0	*calc*
	65.5	...	62.8	60.3	...	*obs*

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As noted earlier, the partition function used in this theory reduces to a solid partition function when $V = V_s$ and to a gaseous partition function when $V \gg V_s$. Thus it is reasonable to expect that this partition function will also represent the surface layer, if the density gradient is taken into account. For a simple close packed liquid such as argon, it is supposed that the molecules on the surface will orient such that each molecule will tend to have six neighbors in the same layer, three neighbors below and three above. Only E_s, the bulk energy of sublimation, should be appreciably different for a surface and a bulk molecules. The energy E_{s_i} of a molecule in the ith surface layer is given by the relationship.

$$E_{s_i} = E_s\left(\frac{6}{12}\frac{\rho_i}{\rho_i} + \frac{3}{12}\frac{\rho_{i+1}}{\rho_i} + \frac{3}{12}\frac{\rho_{i-1}}{\rho_i}\right) \tag{27}$$

Here ρ_i is the density of the ith layer and the subscript increases with depth in the liquid. If $\rho_{i+1} > \rho_i$, then more molecules are in the ith + 1 layer with respect to the ith layer. That is, the molecules in the ith + 1 layer are bound more tightly, or $|E_{s_{i+1}}| > |E_{s_i}|$. When i is the top liquid layer and $(i - 1)$ the first gas layer, we can write

$$\rho_{i-1}/\rho_i = e[-(E_s/2RT)(1 - T/T_c)] \tag{28}$$

This corresponds to a molecule in the top liquid layer possessing six nearest neighbors in the same plane, three in the neighboring liquid plane, but none in the gas layer at low temperatures. A molecule in the first gas layer, on the other hand, has only the three neighbors in the first liquid layer and no neighbors in the same gas layer or in the gas layer above. Thus, the extra binding energy of a molecule in the first liquid layer over one in the first gas layer corresponds to six more neighbors out of a possible twelve or an extra binding energy of $E_s/2$. In keeping with this result the exponent of equation (28) reduces to $E_s/2RT$ at low temperatures and vanishes at $T = T_c$, as it must since the densities become equal at the critical temperature.

The Gibbs free energy per mole, $G_i = A_i + PV_i$, for each surface layer may now be calculated by means of equations (27) and (28) by using an iterative process to determine the ρ_i's. The surface tension, γ, may be calculated from the relationship

$$\gamma = \sum_i \Delta G_i \cdot \frac{0.9165}{V_i}\left(\frac{V_s}{N}\right)^{1/3} \tag{29}$$

where ΔG_i is the difference in free energy of one of the surface layers and the bulk liquid. The remaining factor is the volume of a layer of surface lattice one cm² in area assuming a face centered cubic lattice. Other types of packing would give a different factor.

Surface tensions have been calculated for argon, nitrogen, and methane at several temperatures. The results are given in Table 5. The columns labeled 1st, 2nd, and 3rd are the per cent contributions to the

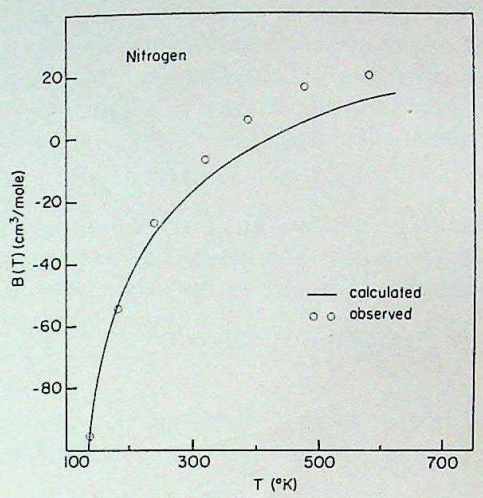

Figure 6. The second virial coefficients of nitrogen versus temperature.

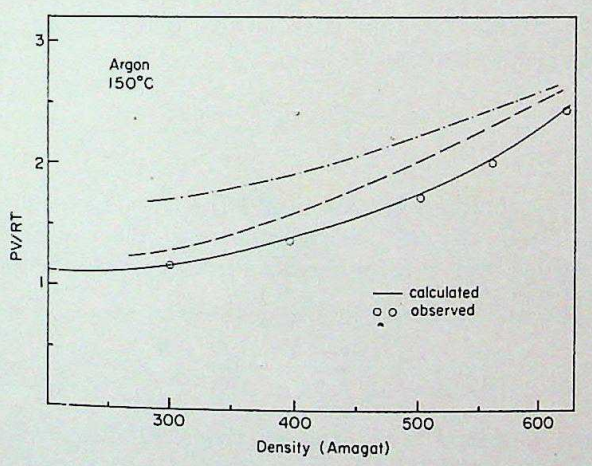

Figure 7. Compressibility factors of argon versus densities at 150° C. —— represents values from Significant Structure theory; — —represents Kirkwood's values; —·—· represents Hirschfelder's values.

Table 5. Surface Tension of Liquids (dyne/cm)

T (°K)	V_l (cc)	V_g (cc)	1st %	2nd %	3rd %	Surface Tension calc	Surface Tension obs	Δ (%)
Argon								
83.85(m)	28.90	10,208	87.16	12.84	0	13.78	13.5	+2.09
85.5	29.08	8,493	86.45	13.55	0	13.43	13.1	+2.52
87.29(b)	29.33	6,944	85.87	14.13	0	13.02	12.6	+3.33
90.0	29.80	5,246	85.35	14.65	0	12.22	11.9	+2.69
Nitrogen								
63.14(m)	32.59	41,620	90.92	9.08	0	12.00	12.05	−0.41
70.0	33.71	15,534	88.66	11.34	0	10.58	10.50	+0.76
77.34(b)	35.05	6,097	86.53	13.47	0	8.90	8.98	−0.89
90.0	37.84	2,169	78.52	17.06	4.42	6.33	6.20	+2.09
Methane								
90.65(m)	34.11	62,499	95.36	4.64	0	15.72	18.20	−13.63
100.0	34.99	22,432	90.35	9.65	0	15.65	16.15	−3.09
111.67(b)	36.35	9,669	87.99	12.01	0	13.41	13.70	−2.11
120.0	36.82	3,249	85.46	14.54	0	12.51	11.90	+2.27

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surface tension from the respective layers. The Eötvös constant, K_E, is defined by

$$K_E = \gamma V^{2/3}/(T_c - T) \tag{30}$$

and are given in Table 6.

Table 6. The Eötvös Constants

T (°K)	K_E (*calc*)	K_E (*calc*) average	K_E (*obs*)
Argon			
83.85(*m*)	1.903	1.916	2.02
85.5	1.916		
87.29(*b*)	1.926		
90.0	1.911		
Nitrogen			
63.14(*m*)	1.919	1.937	2.00
70.0	1.956		
77.34(*b*)	1.942		
90.0	1.927		
Methane			
90.65(*m*)	1.87	1.91	1.95
100.0	1.89		
111.67(*b*)	1.91		
120.0	1.97		

Transport Properties (9)

Significant Structure theory includes a general theory of transport properties implicitly. It is interesting to note that when the liquid and solid phases have the same free energy, as they do at the melting point, their viscosities differ; i.e., different shear stresses are needed to maintain unit velocity gradients. This difference in viscosity must arise from the change in structure. Although they melt at different temperatures, normal liquids have about the same viscosity (~2 centipoises) at their melting point. Long ago Batschinski (*14*) noted that the reciprocal of the viscosity, the fluidity, is proportional to the volume of the liquid minus a volume very close to that of the solid, i.e., what we call the excess volume. This observation is a natural consequence of the significant structure approach to liquids.

Consider the shear surface between two layers of molecules. Shearing occurs as molecules on either side of the shear plane move into those fluidized vacancies which will relieve the accumulated stress. Obviously, this motion can only occur during the time a vacancy is available for occupancy. The probability of such a vacancy being at a particular point will be proportional to the number of vacancies, $V - V_s$. Thus the rate of shear, the fluidity, is proportional to this excess volume. This explains Batschinski's results. Moreover, most liquids have about the same concentration of vacancies at their melting points. Since the rate of jumping is nearly the same for each liquid at its T_m, we would expect liquids to have the same visocity at their very different melting points. Most liquids do.

Since there are different types of degrees of freedom (solid-like and gas-like) in the liquid, they both must be taken into account in calculating the viscosity. The shear plane lies between two molecular layers. If a fraction, X_s, of the shear plane is covered by solid-like molecules and the remaining fraction, X_g, by gas-like molecules, then the viscosity, η, which is the ratio of shear stress, f, to rate of strain, $\dot{s}$, is given by

$$\eta = \frac{f}{\dot{s}} = \frac{X_s f_s + X_g f_g}{\dot{s}} = X_s\eta_s + X_g\eta_g = \frac{V_s}{V}\eta_s + \frac{V - V_s}{V}\eta_g \tag{31}$$

Kinetic theory considerations lead us to

$$\eta_g = \frac{2}{3\pi^2 d^2}(\pi mkT)^{1/2} \tag{32}$$

where d is the effective molecular diameter, for the gas-like viscosity. η_s may be calculated by means of reaction rate theory in the following manner.

If K_i is the frequency of a molecule jumping into the ith neighboring empty lattice site when the shear stress, f, is zero, then, when f is not zero, the work helping the molecule to move forward is the force $f\lambda_2\lambda_3$ (where λ_2 and λ_3 represent intermolecular distances in the shear plane) multiplied by the distance the molecule has jumped, $\lambda \cos \theta_i$. Thus the rate of jumping into the ith site is

$$K_i e^{(f\lambda_2\lambda_3\lambda \cos\theta_i/2kT)} \tag{33}$$

The factor 2 is inserted since it is assumed that the top of the potential barrier is halfway between the two equilibrium positions. η_s may then be written

$$\eta_s = \frac{f}{\dot{s}} = f \Big/ \left\{\sum_i K_i \frac{X \cos\theta_i}{\lambda_1} e^{(f\lambda_2\lambda_3\lambda \cos\theta_i/2kT)}\right\} \tag{34}$$

where λ_1, is the distance between the two molecular shearing planes. Expanding the exponential, we obtain

$$\eta_s = f \Big/ \left\{\frac{\lambda}{\lambda_1}\sum_i K_i \left(\cos\theta_i + \frac{f\lambda_2\lambda_3\lambda \cos^2\theta_i}{2kT}\right)\right\} \tag{35}$$

Since the sites are randomly distributed over the solid angle, we may average $\cos\theta_i$ (which becomes zero) and $\cos^2\theta_i$ (which becomes 1/3):

$$\eta_s = \frac{1}{\sum_i k_i} \cdot \frac{\lambda_1}{\lambda^2\lambda_2\lambda_3} \cdot 6kT \tag{36}$$

Now according to this liquid theory a molecule can jump into any of the neighboring $n(V - V_s)/V_s$ vacancies, and so from absolute reaction rate theory we have

$$\sum_i k_i = \kappa \cdot \eta \frac{V - V_s}{V_s} \cdot \frac{kT}{h} \cdot \frac{F^{\ddagger}}{F} e^{-\epsilon_0/RT} \tag{37}$$

where F and $F^{\ddagger}$ are the partition functions for the molecule in the initial and activated states, and $\epsilon_0 = (a'E_s/RT)(V_s/V - V_s)$ is the activation energy. F and $F^{\ddagger}$ are given by

$$F = \frac{e^{E_s/RT}}{(1 - e^{-\theta/T})^3} \cdot [1 + n_h e^{-\epsilon/RT}]$$

$$F^{\ddagger} = \frac{e^{E_s/RT}}{(1 - e^{-\theta/T})^2} \cdot [1 + n_h e^{-\epsilon/RT}] \tag{38}$$

taking $\lambda^2\lambda_2\lambda_3/\lambda_1 = V_s/N$ and substituting equations (37) and (38) into (36), we obtain

$$\eta_s = \frac{Nh}{V} \cdot \frac{1}{1 - e^{-\theta/T}} \cdot \frac{6}{\kappa n} \frac{V_s}{V - V_s} e^{a\, E_s V_s/RT(V - V_s)} \tag{39}$$

Substitution of equations (39) and (32) into (31) then yields an expression for the viscosity.

The self-diffusion coefficient, D, may be calculated from the relationship

$$D = \frac{kT}{\zeta(V_s/N)^{1/3} \cdot \eta} \tag{40}$$

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where ζ is the effective number of neighbors of a molecule lying in the same plane. For a close packed structure this is six.

Figures 8, 9, and 10 show the viscosity of liquid argon, of liquid sodium, and the self-diffusion coefficient of molten sodium.

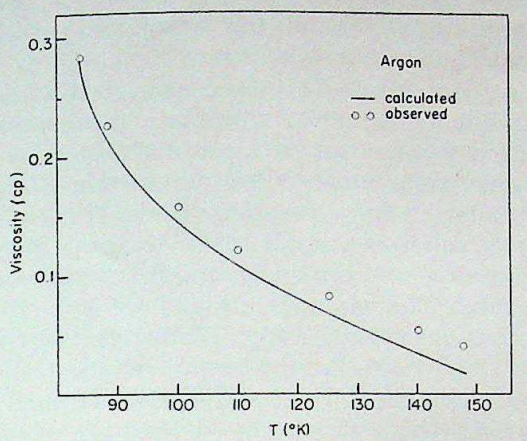

Figure 8. Viscosity of liquid argon in centipoises versus temperature.

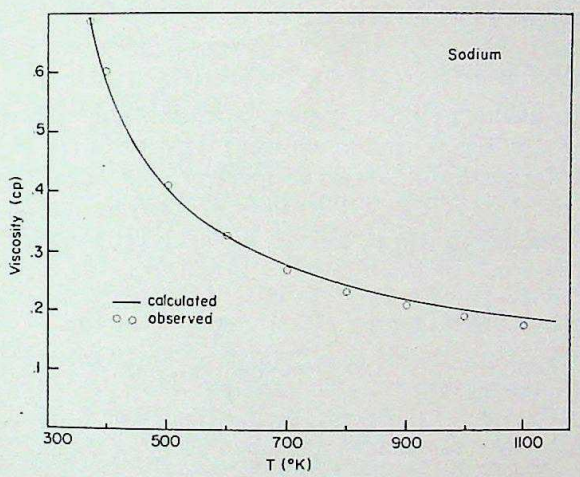

Figure 9. Viscosity of liquid sodium in centipoises versus temperature.

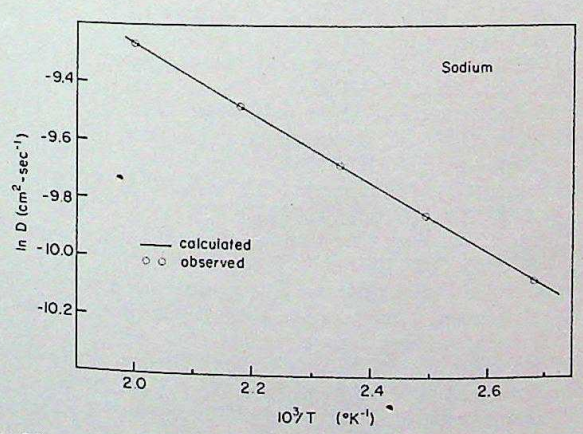

Figure 10. Self-diffusion coefficient of molten sodium versus temperature.

Current Investigations

At this time we are applying significant structure theory to water, oxygen, and binary mixtures. We are also doing some further work on molten metals. The results of these investigations will appear in the near future. In the article we give the reader a brief indication as to how we are proceeding on these different liquids.

Binary Mixtures

A most exciting problem currently being considered is binary mixtures. If we can successfully apply the theory to mixtures, then a whole new panorama of problems is brought into view. Consider the reaction

$$aA + bB \rightleftharpoons cC + dD$$

One can show that the net rate, r, of this reaction is

$$r = \kappa \frac{kT}{h} F^{\ddagger} (\lambda_A{}^a \lambda_B{}^b - \lambda_C{}^c \lambda_D{}^d)$$

where κ is the transmission coefficient and $F^{\ddagger}$ is the partition function of the activated complex. The λ's are the absolute activities of the respective species and must be obtained from the liquid theory. Thus, if we are able to compute the activities, we will be able to calculate reaction rates and solubilities.

The partition function we are using for binary mixtures is the following

$$f = \frac{(N_1 + N_2)!}{N_1!\, N_2!} \cdot f_1 \cdot f_2 \cdot [(1 + n_h e^{-\epsilon/RT}\, e^{E_s/RT}]^{N(V_s/V)}$$

where

$$f_i = \left[\frac{1}{(1 - e^{-\theta_i/T})^3}\right]^{N_i(V_s/V)} \cdot \left[pf_{tr} \cdot \frac{eV}{N_i}\right]^{N_i(V - V_s)/V}$$

The factorial term is the usual mixing factor which arises from assuming random mixing of the two different species. f_1 and f_2 are the solid- and gas-like portions of the partition functions for the respective species. The main problem with mixtures is to determine how the parameters E_s, V_s, n, and a vary with concentration. Many years ago van der Waals suggested that the energy and volume should vary in the following way:

$$E_s = X_1{}^2 E_{s_1} + 2X_1X_2(E_{s_1}E_{s_2})^{1/2} + X_2{}^2 E_{s_2}$$

$$V_s = X_1 V_{s_1} + X_2 V_{s_2}$$

where X_1 and X_2 are the respective mole fractions, and the E_s's and V_s's are the parameters for the pure components. It is wishful thinking to assume that these equations will work for liquids. They are much more applicable to gases. Averaging formulas developed by Prigogine (*13*) seem more promising. We are presently developing procedures to determine the parameters as functions of concentration.

Water

An interesting problem is presented by water due to the strong hydrogen bonding and the presence of different species. We assume that water is composed primarily of two species: "structured" water molecules which are bound in a rigid lattice and thus do not rotate and "unstructured" water molecules which are assumed to be freely rotating. At low temperatures the structural water molecules are the predominant species. As the temperature increases, more and more molecules begin to rotate until several hundred degrees above the boiling point they are all freely rotating. The ratio of the two species is controlled by an equilibrium constant. The partition function is

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$$f = f_s^N(V_s/V) \cdot f_g^{(N/2)}(V - V_s/V)$$

where

$$f_s = \frac{e^{E_s/RT}}{(1 - e^{-\theta/T})^3} \cdot [1 + n_h e^{-\epsilon/RT}] \cdot pf_{\text{vib}} \cdot \left[\frac{1 - e^{-E_0/RT}}{(1 - e^{-\theta/T})^3} + e^{-E_0/RT} \cdot pf_{\text{rot}}\right]$$

$$f_g = \left[pf_{\text{tr}} \cdot \frac{eV}{N} \cdot pf_{\text{vib}} \cdot pf_{\text{rot}}\right]^2 + pf_{\text{tr}_d} \cdot \frac{eV}{N/2} \cdot \frac{8\pi^2 IkT}{2h^2} \cdot pf_{\text{vib}}^2 \cdot pf_{\text{rot}}^2 \cdot \frac{e^{D/RT} - 1}{1 - e^{-h\nu/kT}}$$

$$E_s = \frac{KE_{s_1} + E_{s_2}}{1 + K}$$

$$V_s = \frac{KV_{s_1} + V_{s_2}}{1 + K}$$

At low temperatures f_s reduces to a partition function for the structured water molecules which are treated as 6-degree Einstein oscillators. At higher temperatures f_s becomes a partition function for freely rotating water molecules. Since the strong hydrogen bonds will cause clustering in the gas phase, f_g includes a term for dimer water molecules. E_s and V_s are related by an equilibrium constant to the sublimation energies and solid volumes of the structured and unstructured species. Preliminary calculations indicate that the results for water will be nearly as good as has been obtained by significant structure theory for other pure liquids.

Conclusions

This theory can be applied to a tremendous range of liquids, and the degree of success has ranged from excellent to good. There is no other theory which will work as well for so many different classes of liquids. The theory rests on a model of the liquid state which is reasonable and successful. Its usefulness cannot be doubted. Given some properties of the solid (the sublimation energy, the volume of the solid, and the Einstein characteristic temperature) all the thermodynamic properties may be calculated from equations (12) and (13) and similar expressions. To determine n and a, the liquid volume, V_m, at the melting point must be known. Using an initial guess of V_m and a method of successive approximations, we can obtain consistent values for n and a. In those cases when the properties of the solid are unknown or for some special liquids, the parameters E_s, θ, and V_s may be determined from the experimental pressure, entropy, and liquid volume at the melting point.

The usefulness of the model is clear; the meaning of the model needs careful elaboration. Since the model can be applied to so many different liquids, can be used to calculate transport properties and surface tensions, and can be used to compute the radial distribution function, the basic tenents of the theory, while undoubtedly needing refinement, are none the less good approximations. Certainly the idea that a molecule in the liquid state sometimes possesses external vibrational degree of freedom and at other times translational degrees of freedom cannot be wrong. The division of these degrees of freedom into their respective fractions V_s/V and $(V - V_s)/V$ is a good first approximation and the estimation of the degeneracy factor needs elaboration.

A criticism frequently raised against this theory is that it has a number of adjustable parameters. We have tried to point out in this article that there are no adjustable parameters. The parameters E_s, θ, and V_s are obtained from the solid state. If there were a theory of solids, we could calculate these quantities; since there is not, we must obtain them by experimentation. The parameters a and n maybe obtained from equations (7) and (10). If all spherical molecules exactly obeyed a reduced equation of state, the same dimensionless values for n and a could be used for all liquids. In terms of a reduced equation of state an analogy can be drawn between T_c and a, and V_c and n. Since this theory is applicable to a greater degree of accuracy than a reduced equation, it is necessary to use accurate values of n and a.

Acknowledgment

The authors wish to express appreciation to the U. S. Army Ordnance under contract DA-ARO(D)-31-124-G298 for partial financial support of this research, and one of them (R.P.M.) expresses appreciation to the National Institutes of Health for an NIH Postdoctoral Fellowship.

Literature Cited

(1) Eisenstein, A. and Gingrich, N., *Phys. Rev.*, **62**, 261 (1942).
(2) Walter J. and Erying, H., *J. Chem. Phys.*, **9**, 393 (1941).
(3) Eyring, H., *J. Chem. Phys.*, **4**, 283 (1936).
(4) Fuller, E. J., Ree, T., and Eyring, H., *Proc. Nat. Acad. Sci.*, **45**, 1594 (1959).
(5) Thomson, T. R., Eyring, H., and Ree, T., *Proc. Nat. Acad. Sci.*, **46**, 336 (1960).
(6) Chang, S. and Park, H. S., *J. Korean Chem. Soc.*, **7**, July (1963).
(7) Henderson, D., Eyring, H., and Felix, D., *J. Phys. Chem.*, **66**, 1128 (1962).
(8) McLaughlin, D., To be published.
(9) Carlson, C. M., Eyring, H., and Ree, T., *Proc. Nat Acad. Sci.*, **46**, 649 (1960).
(10) Carlson, C. M., Eyring, H., and Ree, T., *Proc. Nat. Acad. Sci.*, **46**, 333 (1960).
(11) Ree, T. S., Ree, T., and Eyring, H., *Proc. Nat. Acad. Sci.*, **48**, 501 (1962).
(12) Chang, S., *et al.*, Second Symposium on Thermophysical Properties, January, 1962. Princeton University, Princeton, New Jersey.
(13) Prigogine, I., "The Molecular Theory of Solutions," Interscience Publishers, Inc., New York, 1957, chap. 9.
(14) Batschinski, A. J., *Z. physik. Chem.*, **84**, 643 (1913).

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A Chem Ed SYMPOSIUM

Kinetics for the Undergraduate

Introduction

This is an appropriate time to consider the place of kinetics in the undergraduate curriculum. In the not-too-distant-past, the subject was discussed primarily at two places. In the general chemistry course, kinetics appeared in inappropriate and generally incorrect derivations of the equilibrium constant expression. In the physical chemistry course, instruction in kinetics dealt largely with integration of rate laws of various forms. The relevance of kinetics in elucidation of reaction mechanisms was ignored, and even if not ignored, the instruction came too late to be of use in preceding undergraduate courses.

With presentation of more modern physical chemistry topics, e.g., molecular spectroscopy and quantum mechanics, instruction in kinetics is being crowded out of the standard undergraduate course in physical chemistry. The effect of this situation can be rectified and, in fact the situation improved with introduction of more meaningful discussion of kinetics in the freshman course. A reasonably sophisticated introduction to reaction kinetics and the meaning of rate laws in terms of reaction mechanisms is possible in general chemistry; this can be done within the framework of some of the existing textbooks or with the assistance of an appropriate elementary monograph.[1] Rate laws for chemical reactions then can be introduced where relevant in all later instruction in analytical, inorganic, and organic chemistry.

It is regrettable that textbooks on the reactions of chemical substances, both organic and inorganic, do not give more rate laws. Many textbooks give none. A model which authors of textbooks could imitate is Systematic Inorganic Chemistry by Yost and Russell,[2] in which there is, on the average, one rate law for every seven pages. Both the utility of kinetic data in elucidation of reaction mechanisms and their limitation can be illustrated very nicely with reference to specific examples in courses which focus attention on the chemical reactions. Theory and practice in chemical kinetics should be presented together.

The Division of Chemical Education sponsored a one-half day session on "Kinetics in the Undergraduate Curriculum" at the Los Angeles Meeting of the American Chemical Society in April, 1963. Six speakers discussed various facets of the subject, and it is fortunate that the following papers based on five of these contributions are being published in the JOURNAL OF CHEMICAL EDUCATION, which has also published other papers in the recent past on this same general topic.[3] In addition to the five papers being published here, a paper on "Reaction Rate Discussions Appropriate to the Elementary Organic Chemistry Course" was presented by J. D. Roberts of the California Institute of Technology. His paper discussed use of energetics of elementary reactions as an aid in deciding upon the correct mechanism for an organic reaction. The substance of this discussion can be found in his forthcoming book.[4]

It is hoped that those with interesting and novel ideas regarding instruction in kinetics will communicate these ideas to others by means of publication in THIS JOURNAL.

Edward L. King, *Symposium Chairman*
University of Colorado, Boulder

[1] For instance, KING, E. L., "How Chemical Reactions Occur," W. A. Benjamin, Inc., New York, N. Y., 1963.
[2] YOST, D. M., AND RUSSELL, H., JR., "Systematic Inorganic Chemistry," Prentice-Hall, New York, 1944.
[3] GUGGENHEIM, E. A., "Textbook Errors IX: More About the Laws of Reaction Rates and of Equilibrium," J. CHEM. EDUC., 33, 544 (1956).
EDWARDS, J. O., "Reaction Rates for the Practical Chemist," J. CHEM. EDUC., 34, 47 (1957).
TAUBE, H., "The Role of Kinetics in Teaching Inorganic Chemistry," J. CHEM. EDUC., 36, 451 (1959).
BENSON, S. W., "Some Aspects of Chemical Kinetics for Elementary Chemistry," J. CHEM. EDUC., 39, 321 (1962).
[4] ROBERTS, J. D., AND CASERIO, M. C., "Basic Principles of Organic Chemistry," W. A. Benjamin, New York, 1963.

Now forasmuch as the Elements, unless they be altered, cannot constitute mixt bodies; nor can they be altered unless they act and suffer one from another; nor can they act and suffer unless they touch one another, we must first speak a little concerning contact or mutual touching, Action, Passion and Reaction.

DANIEL SENNERT (1660)
quoted by W. J. Moore, "Physical Chemistry"

The effectiveness of a chemical process in industry may depend upon the rate of a particular reaction: an increase in rate by a factor of 10 can change red ink to black ink.

E. L. KING (1963)
"How Chemical Reactions Occur"

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Concepts of Time in Chemistry

Chemistry is concerned with substances and with their transformations into other substances. One might expect therefore that the theoretical structure of chemistry would deal perhaps 50% with the nature of substances and 50% with the processes of transformation. The proportions are, however, very different, in part because a description of transformation processes at the molecular level has turned out to be peculiarly difficult.

About a century ago, Alexander Williamson in a paper on the implications of his synthesis of unsymmetrical ethers, commented (*1*):

> We are all agreed that chemistry is concerned with the material process of the transformations and changes which matter undergoes, and that the study of the properties of matter in themselves, as long as they undergo no change, belongs to physics. . . . When we study a molecule by itself, we study it physically; chemistry considers the *change* effected by its reaction upon another molecule, and has to describe the process by which that change is effected. A chemical decomposition should therefore be represented by the juxtaposition of the formulae of the reacting substances, and by effecting in these formulae the change which takes place in the mixture.

Williamson was well aware that no theory of chemical *transformation* existed in his time, and that a fundamental step away from the statical description of molecules was necessary in order to describe chemical change. His paper entitled "Suggestions for the Dynamics of Chemistry Derived from the Theory of Esterification" begins as follows (*2*):

> The human mind is only capable of understanding complicated phenomena when prepared by the study of simpler ones; and one of the most remarkable illustrations of this necessary order is afforded by the preparation of dynamical laws, by the consideration of statical facts. In statics we consider phenomena in a state of rest, while in dynamics we study their change; and this distinction has been concisely stated by saying that the transition from the statical to the dynamical point of view consists in superadding the consideration of *time* to that of space. . . . There are many *prima facie* evidences that *time* is necessary for chemical action—but this fact, although it has been noticed, has not yet entered into the explanation of phenomena.

Two comments should be made about this quotation. Firstly, Williamson identifies time as the necessary ingredient of any theory that is truly chemical. Secondly, his claim that time had up till then not entered into the explanation of chemical phenomena, if true, makes his theories the first truly chemical theories.

It is tempting to characterize the history of chemistry as a continual attempt to avoid the explicit incorporation of time into chemical theories. Williamson rejected the then current view that atoms and molecules are at rest. He called on chemists to study the "degree and kind of motion" possessed by atoms and to "reduce to this one fact the various phenomena of change, which are now attributed to occult forces (*2*)."

Williamson pointed to one piece of evidence of molecular motion in chemical reactions, the etherification of alcohol by sulfuric acid. It had been demonstrated that ethyl hydrogen sulfate is first formed, but that the latter gives up its ethyl group again to a second alcohol molecule:

$$C_2H_5OH + H_2SO_4 \rightarrow C_2H_5SO_4H$$

$$C_2H_5SO_4H + C_2H_5OH \rightarrow C_2H_5OC_2H_5 + H_2SO_4$$

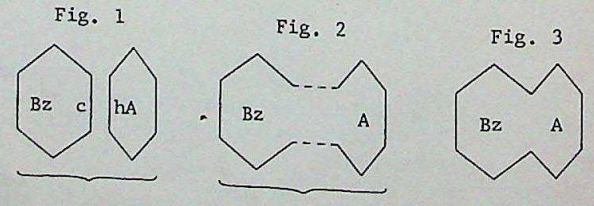
Further, the two-stage process could be demonstrated by introducing a different alcohol, for instance amyl alcohol, for the second step. The repeated alternating process of a sulfuric acid molecule taking on an ethyl group from one alcohol molecule and supplying it to another almost necessitates molecular motion. Williamson also pointed to the fact of diffusion as clear evidence of molecular motion even in the absence of chemical reaction. He realized that the incorporation of motion into our concepts of chemical systems was the simplest way of incorporating the dimension of time into our atomic models.

A mechanism for a double displacement reaction was proposed by Auguste Laurent at about the same period. Laurent conceived of molecules in terms of geometric figures whose faces were occupied by atoms or groups. The benzoyl chloride-ammonia reaction

$$C_6H_5COCl + HNH_2 \rightarrow C_6H_5CONH_2 + HCl$$

he represented in terms of hexagonal figures, this being almost certainly the first time a hexagon was associated with a benzene derivative (*3*):

> To render the reciprocal replacement of the two residues intelligible, I will suppose, that in ammonia and chloride of benzoyl the atoms are arranged so as to form hexagonal figures.



Bz and A, Fig. 1, represent chloride of benzoyl and ammonia at the moment when they react upon one another, the face *c* being opposed to the face *h*, which is to be set free. Bz and A, Fig. 2, represent the two residues during the reaction, and Bz, A, Fig. 3, the two residues after the reaction having reciprocally filled up the two voids formed in A and Bz [by the removal of the chlorine and hydrogen "faces"].

Presented as part of the Symposium on Kinetics in the Undergraduate Curriculum before the Division of Chemical Education at the 144th Meeting of the American Chemical Society, Los Angeles, California, April, 1963.

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August Kekulé in his classic 1858 paper on the chain-forming capacity of carbon atoms, referred to Laurent's mechanistic proposal and devoted a section of the paper to a discussion of the "process that occurs during chemical metamorphoses" feeling that "the main cause of the lack of clarity in certain points of view is the one-sided conception held about such chemical changes (*4*)."

Kekulé's proposal, which he believed to be applicable to all reactions, was as follows (*5*):

> When two molecules react, they first attract each other by virtue of their chemical affinity and align themselves next to each other. The affinities of the individual atoms then cause atoms which previously belonged to different molecules to come into intimate contact. For that reason the group that was divided in one direction prior to reaction, now falls apart in another direction, thus:
>
> | Before | During | After |
> |---|---|---|
> | a \| b | a b | a b |
> | a′ \| b′ | a′ b′ | a′ b′ |
>
> . . . In the majority of cases, the force that occasioned the molecules to come together also causes the resulting decomposition; on the other hand it is conceivable, and cases of this sort exist, that the affinities of the atoms belonging to the different molecules will lead to the association of the molecules, but, at least under the same conditions, will not lead to the decomposition of the atomic aggregate so formed into two new molecules.
>
> Of especial interest, therefore are the cases in which the intermediate state [*Zwischenstadium*], the molecular aggregate, can be retained, but where by deliberate changes in the conditions, the decomposition can be brought to completion.

Kekulé has here proposed, probably for the first time, the mechanism we still accept for the hydrogen-iodine reaction. Both he and Laurent proposed an intermediate stage between initial and final states and Kekulé pointed to the importance of isolating such intermediate stages or molecular aggregates. He referred to a reaction of cacodyl chloride, $As(CH_3)_2Cl$, with chlorine where an addition product could be isolated which on mild heating decomposed into methyl chloride and arsenic monomethyl dichloride. He assumed that NH_4Cl and PCl_5 were analogous to these intermediate addition compounds except that they decomposed only in one direction, the direction from which they were formed.

In a footnote Kekulé explained the phenomena of mass action and catalysis as due to a pervasive loosening of the bonds between atoms due to affinities between unbonded molecules. If two substances are both reagents, larger concentrations lead to a greater weakening of bonds, hence to faster reaction. If one of the bond-weakening substances is not a reagent, it acts as a catalyst (*5, 6*).[1]

The historical background here given is very different from the one usually mentioned when introducing chemical kinetics, namely, Wilhelmy's study of the inversion of sucrose in 1850, Guldberg and Waage's studies on mass action in the 1860–70's and Arrhenius' work on activation energy in 1899. The *idea* of a transition state or intermediate state predates by many decades the mathematical procedure for obtaining its energy. Kinetics does not deal only with the quantitative elucidation of rates or reaction. Its main value to chemists is in the aid kinetics gives in the elucidation of mechanisms. Therefore *both* historical strands, the concern with mechanism—that is, with the nature of the process of chemical change—and the concern with the variation of reaction rates with changing conditions, were necessary for the modern emphasis on kinetics. Unfortunately however, kinetics still is often taught tucked away in a corner of a physical chemistry course, seemingly completely unrelated to the mechanisms discussed in organic and inorganic chemistry courses. The concern for an understanding of the *process* of transformation, and for the incorporation of the time dimension in chemical discussions is seen to have a venerable history. In what ways has time been incorporated into chemical concepts?

[1] A very rudimentary idea of a transition state was already envisaged by William Higgins in 1789 in discussing the reaction of iron with hydrochloric acid. *Cf.* ref. (*6*).

Concepts of Time

Diffusion. As Williamson pointed out, time is involved in the phenomenon of diffusion and is incorporated in the simple application of a Newtonian model to chemical substances. The movement of material is explained in terms of velocities possessed by individual molecules. But any property possessed by a molecule as a whole cannot by itself account for transformations occurring within the molecule.

The First Law of Thermodynamics. The first law of thermodynamics deals with the convertibility of different forms of energy and enunciates the principle of energy conservation. Time enters only implicitly, convertibility implying at least two states of a system at different times. But as far as the first law is concerned, energy conversion can occur in any direction. Time only appears as a way of separating before and after. There is no necessary connection between a set of events and time. As a mathematical model all that is needed is the pair of numbers 0 and 1, the 0 representing the earlier and the 1 the later state. The numbers may be interchanged without breaking the first law. If heat is gained in a reaction going in one direction, exactly the same amount of heat will be lost for the same number of moles of material reacting in the opposite direction.

The Second Law of Thermodynamics. The second law, in contrast with the first, demands an intrinsic connection between time and the world of events. It is the chemist's way of recognizing the interconnection of space and time demanded by relativity theory. A chemical system under certain conditions undergoes certain chemical changes and not others. The events occur in a particular sequence in time. Time's "arrow" is introduced imposing a serial order on certain sets of states. In a sense all chemical changes are spontaneous changes. Under specified conditions, change occurs only in a given direction, the direction of free energy decrease. To force a reaction in the reverse direction is simply to change the state of the system until the reverse chemical change involves a free energy decrease. A mathematical model for the time concept in the second law of thermodynamics might be the continuum of increasing real positive numbers. Any number must be followed by a larger one, as any state must be followed by one of lower energy. Only the uni-directional character of time is required here, not any quantitative measure of time. There are no specific numbers indicated on the number continuum.

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Perhaps a better model for time as here discussed is as a lengthening ribbon whose only specification is that it always grows longer without any specification as to its rate of growth.

Kinetics. The second law of thermodynamics could predict a future state from a present one but was quite incapable of predicting the time required to attain the future state. No measure of time, no time unit was specified in the equations of thermodynamics. There seemed to exist an unbridgeable gulf between thermodynamics and the study of chemical kinetics. For kinetics uses a time concept incorporating a unit of time, against which the quantity of chemical change per unit time can be measured. That unit of time is in the last resort dependent on certain periodic phenomena, the rotation of the earth, the pulse beat, the swing of the pendulum, the oscillation of a balance wheel, a vibration in a molecule, one of which is taken to be a truly periodic motion in terms of which other time spans are determined. It is perhaps of more than incidental significance that the transition from the second law of thermodynamics to kinetic studies of rates of chemical change has its exact counterpart in the history of geology. Until the turn of the century geologic events could only be ordered on a serial time scale, with almost no indication of the quantitative time spans between events. Radioactive dating techniques have now supplied a *measure* of time so that a definite date can be assigned to a geologic event.

Two paths have been followed theoretically in relating kinetic data and energy conceptions. The first, the collision theory, employing a Newtonian model, incorporates time by using molecular velocities and attempts to determine the number of favorably oriented collisions which also have the requisite amount of energy.

The second, known as the theory of absolute reaction rates, bridges the gulf between thermodynamics and kinetics, that is between energy and time units by means of the Planck expression $E = h\nu$. Here an equivalence, a conversion factor between energy and frequency is postulated, making it dimensionally possible to deduce rate data from energy data. The particular frequency that introduces the time dimension into thermodynamic relations is the computed frequency of the loose bond in the transition complex which is broken during the decomposition of the complex. (*7*).

The application of thermodynamics in the theory of absolute reaction rates implies that the transition state can be treated as any other thermodynamic state, that its properties are independent of the path by which it was attained, that there exists an equilibrium between the initial state and the transition state and one between the transition state and final state. Much has been written about this assumption and it has been repeatedly questioned (*8*).

Clearly, if the transition state were in equilibrium with the initial state no chemical change would occur. As Eyring and Eyring have recently pointed out (*9*), The Introduction to the recent British symposium on the transition state validly points out that the greatest success of transition state theory "has been not in the accurate prediction of the rates even of the simplest reactions, but in providing a framework in terms of which even the most complex reactions can be better understood (*10*)."

Particularly organic chemists have attempted to describe reaction paths in terms of transition states and intermediates, endowed with all the properties of stable thermodynamic states. We are in danger at times of forgetting that by so doing we are once more removing the time dimension and are attempting to explain a continuous temporal process in terms of a set of purely static spatial images. In a reaction

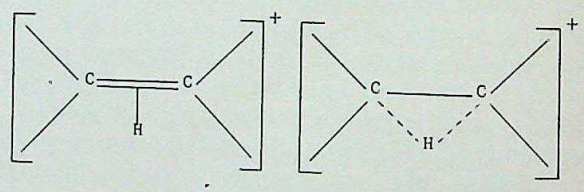
$$A + B \rightarrow C^* \rightarrow \text{products}$$

where C^* is an assumed intermediate, if a different reaction

$$P + Q \rightarrow C^{\ddagger} \rightarrow \text{products}'$$

gives even a slightly different proportion of products, it is sometimes assumed that the two intermediates C^* and $C^{\ddagger}$ cannot be identical. It is assumed that the same intermediate under the same conditions must always lead to exactly the same products. This of course must be true if C^* and $C^{\ddagger}$ are proper thermodynamic entities; but that is precisely the question at issue. What sort of minimum stability must an entity have, how deep must the energy trough be to allow us to be certain that its decomposition is not influenced by the path by which its conformation was attained?

As an example, we may cite the discussion of a number of years ago regarding the existence of two species I and II



I II

produced from different sources and leading to different products and showing markedly different rates of deuterium exchange. The π-complex I was postulated as an intermediate during the hydration of olefins, while the hydrogen bridged intermediate II was suggested as perhaps only a transition state during the deamination of isobutylamine. Now according to resonance theory, the nuclei in I and II are in such similar locations that I and II should simply be resonance structures approximating the actual distribution of nuclei and electrons. Yet it was felt that since the two postulated intermediates led to different products, they cannot have the same structure and were considered as structural isomers (*11*). An alternative proposal is, of course, that I and II may very well represent the same momentary set of locations of nuclei and electrons but that the energy trough of the intermediate is so shallow that the future course is markedly dependent on the past history, on the *direction* of motion of the particles constituting the intermediate (*12*). To represent such a difference in history by the two structures I and II is to translate

A metastable state such as the activated complex arising from reactants almost always goes on to products and does not equilibrate in the way characteristic of stable states. Instead, at equilibrium, products pass in the reverse direction through the metastable, activated states to maintain the balance characteristic of equilibrium.

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temporal differences into differences in spatial arrangement. It is one more attempt to avoid the dimension of time.

The above considerations suggest that perhaps organic chemists have reached the point where the profusion of postulated intermediates and transition states may necessitate in the not too distant future a shift from the purely spatial imagery now current to a truly dynamic model, one that attempts to depict the continuous processes of chemical change.

Kinetics in the Earlham Curriculum

What is being done at Earlham in the way of teaching kinetics can be stated rather briefly. We have felt that to relegate kinetics to a late portion of a junior or senior physical chemistry course is both temporally and spatially wrong. If the physical chemistry course is the capstone course, kinetics is taught too late. It is taught *after* most of the chemistry to which it is applicable has been described and therefore described inadequately. And precisely the same reason demands that kinetics not be taught as one of a number of selected topics of theoretical chemistry, but that it should be taught instead within the context of organic and inorganic subject matter that gives kinetics its relevance to chemistry.

On the other hand, we did not feel that the subject could be adequately treated merely by occasional mention in other courses. Somewhere the kinetic approach had to be presented systematically. Our solution, which was in keeping with our general approach at Earlham of tying each course as far as possible around one or two central concepts, was to design a junior level course focussing on the concepts of space and time in chemistry, that is, dealing with the topics of stereochemistry, kinetics and mechanisms (*13*). Each of these topics had been introduced many times in earlier courses; in this course earlier fragmented information was synthesized and systematically extended. Stereochemistry was discussed in terms of both inorganic and organic compounds and included a more than cursory look at conformational analysis. Kinetics included discussion of the conceptual bases and uses of the theory of absolute reaction rates. The mechanisms of a number of reactions were discussed in detail with regard to their stereochemical and kinetic properties. At the end of the course each student reported on the kinetics of a reaction recently published in the chemical literature.

In the laboratory we spend about one-third to one-half of the term on kinetic experiments and the balance on qualitative organic analysis. With only majors in the course, the course is taken by six to twelve students. The kinetics work is done mainly on a project basis, the students working in pairs. In addition to one or two classic introductory kinetic experiments, the students work on one or sometimes two detailed kinetic projects. These have included:

- Rate of mutarotation of α- and β-glucose.
- Rate of inversion of sucrose.
- Colorimetric determination of diazocoupling rate.
- Conductivity determination of alkyl halide solvolysis.
- Use of concentration cell for following rapid reactions (*tert*-butyl chloride solvolysis).
- Spectrophotometric study of kinetics of chromic acid oxidation of 2-propanol.
- Basic hydrolysis of benzyl chloride.
- Halogen exchange reaction of alkyl bromides.

Having taken this course in his junior year, the student should be well prepared for independent study projects as a senior or for research participation with a faculty member during the summer preceding his senior year.

Literature Cited

(1) Williamson, A. W., *Chemical Gazette* **9**, 334 (1851), reprinted in "Classics in the Theory of Chemical Combination," O. T. Benfey, editor, Dover Co., New York, **1963**, p. 69–71.

(2) Williamson, A. W., *Notices of the Proceedings at the Meetings of the Members of the Royal Institution*, **1**, 90 (1851–4), reprinted in A. W. Williamson, "Papers on Etherification and on the Constitution of Salts," The Alembic Club, Edinburgh, **1949**, p. 18–20.

(3) Laurent, A., "Méthode de Chimie," Paris 1854, p. 408, translated in "Chemical Method," William Odling, translator, London, **1855**, p. 337, reprinted in "Classics in the Theory of Chemical Combination," *op. cit.*, p. 115.

(4) Kekulé, A., *Ann. Chem.*, **106**, 137 (1858) translated in "Classics in the Theory of Chemical Combination," *op. cit.*, p. 115.

(5) Kekulé, A., *op. cit.*, p. 141, translation p. 118.

(6) Higgins, W., "A Comparative View of the Phlogistic and Antiphlogistic Theories," London, **1789**; second edition reprinted in Wheeler, T. S. and Partington, J. R., "The Life and Work of William Higgins, Chemist (1763–1825)," Pergamon Press, New York, **1960**, p. 192–3. *Cf.* also Wheeler, T. S., *Proc. Chem. Soc.*, **1959**, 221.

(7) Moore, W. J., "Physical Chemistry," 2nd ed., Prentice-Hall, Inc., New York, **1955**, p. 567.

(8) Eyring, H., Ree, T. S., Ree, T., and Wanlass, F. M., in "The Transition State," The Chemical Society Special Publication No. 16, London, **1962**, p. 21.

(9) Eyring, H., and Eyring, E. M., "Modern Chemical Kinetics," Reinhold Publishing Co., New York, **1963**, p. 49.

(10) "The Transition State," *op. cit.*, p. 2.

(11) Cannell, L. G. and Taft, R. W. Jr., *J. Am. Chem. Soc.* **78**, 5812 (1956); discussed by Winstein, S., and Holness, N. J., *J. Am. Chem. Soc.*, **77**, 5562 (1955), esp. fn. 53c.

(12) Waters, W. A. and de la Mare, P. B. D., *Ann. Rep. Progr. Chem.* **50**, 141 (1953).

(13) Strong, L. E. and Benfey, O. T., J. Chem. Educ., **35**, 164 (1958).

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Kinetics—Early and Often

Most chemists agree that the measuring and understanding of the rates of chemical reactions and the mechanism by which they occur are important activities in chemistry. It is therefore somewhat surprising that any reasonable discussion of these areas is normally deferred until the third or fourth year of college. Rates may be mentioned in first year chemistry courses, such as are given in high schools, and the effect of concentration and temperature generalized. But the impression is almost always given that a study of the equation for the net reaction provides evidence for the factors which will affect the rate and that the equation will enable one to predict from it which concentrations will have what effect on the rate.

Chemistry, at these early stages, almost always concerns itself with the nature of the products and the reactants and with the equilibrium between them. But it very seldom deals with that interesting phase of chemistry (represented by the equal sign) through which the reactants do indeed become the products. Rate experiments, when performed, usually corroborate the erroneous idea that the net reaction is intimately related to the rate equation, either by presenting only qualitative evidence as to the effect of concentration, or by dealing with systems in which the mechanism is so simple that there is a pseudo-correspondence between the net reaction and the rate equation. Even when rates and mechanism finally are approached at a higher level, they are seldom dealt with on an experimental basis so that few of the interesting features of mechanisms are met in the laboratory.

There has been considerable justification for this approach in the past when the mechanisms of very few reactions have been completely understood, when rate data have been hard to obtain, and when the majority of chemists have actually been more interested in other areas. None of these "rate determining factors" seems, however, to be effective now.

The studies of rates and mechanisms in chemical reactions has now become central to the understanding of chemistry. Thus, it seems most important to introduce a reasonable discussion of these ideas in the earliest course in chemistry and to reinforce these ideas in each subsequent course, basing the approach as firmly as possible on experimental observations directly accessible to the student.

Let me first list the areas which seem to be important for a minimally educated college graduate (not necessarily a chemist) to have understood in connection with rates and mechanisms and then outline possible sequences by which the total picture might be achieved in the mind of the student. I would choose to classify these ideas into three main categories:

The variables which ordinarily affect the rate of chemical reaction.

The mechanism by which the chemical reaction actually occurs.

The relationship of this mechanism to the equilibrium.

In order to approach most directly the relationship of the variables affecting rate, it seems feasible first to study the rate and to determine experimentally the rate equation. In such an equation the rate of change of some concentration is expressed as a function of certain concentrations and, at any given temperature, a constant. For example,

$$d[\mathrm{HBr}]/dt = k\,[\mathrm{H_2}]\,[\mathrm{Br_2}]^{1/2}$$

for the initial stage of the net reaction

$$\mathrm{H_2} + \mathrm{Br_2} \rightarrow 2\mathrm{HBr}$$

In some cases this differential rate equation can be integrated to give an expression for the concentration of each variable as a function of time and the additional concentrations. For example,

$$\log(\text{ester}) = kt + C$$

for the net reaction

$$\mathrm{H_2O} + \mathrm{CH_3COOC_2H_5} \rightarrow \mathrm{CH_3COOH} + \mathrm{C_2H_5OH}$$

It is interesting to observe that there is no general relation between either the differential or integrated form of the rate equation and the equation for the net reaction. In many cases the rate of reaction is unaffected by changes in concentrations of some of the reactions. For

$$2\mathrm{NH_3}(g) \rightarrow \mathrm{N_2}(g) + 3\mathrm{H_2}(g)$$

on a tungsten surface the rate is independent of the concentration of ammonia. In many other cases the concentrations of substances appear in the rate equation whereas these substances do not appear in the equation for the net reaction. The rate of the net reaction

$$\mathrm{C_{12}H_{22}O_{11}} + \mathrm{H_2O} \rightarrow 2\,\mathrm{C_6H_{12}O_6}$$

in dilute acid is given by

$$d[\mathrm{C_{12}H_{22}O_{11}}]/dt = k[\mathrm{C_{12}H_{22}O_{11}}]\,[\mathrm{H^+}]$$

Furthermore, there is no general correlation between the exponent of each concentration, or the form in which it appears in the rate equation, and the coefficient of the corresponding substance in the equation for the net reaction. Thus, the general rate equation is

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$$\frac{d[\mathrm{HBr}]}{dt} = \frac{k_1[\mathrm{H_2}][\mathrm{Br_2}]^{1/2}}{k_2 + [\mathrm{HBr}]/[\mathrm{Br_2}]}$$

for the net reaction

$$\mathrm{H_2} + \mathrm{Br_2} \rightarrow 2\mathrm{HBr}$$

This comparison of experimental net equations and experimental rate equations quickly leads to the conclusion that any correlation between the two must be quite coincidental or, at least, very well hidden by the intricacies of any relationship.

The effect of temperature on the constant in the rate equation is often experimentally calculable since, in general

$$\frac{d \log k}{d[1/T]} = \frac{\Delta H_{\text{activation}}}{\mathrm{R}}$$

A plot of the logarithm of the rate constant versus the reciprocal of the absolute temperature commonly approximates a straight line from whose slope k may be calculated.

No variables other than certain concentrations and the absolute temperature are ordinarily found to affect the rate of a given chemical reaction.

It is quite true that there are reactions, particularly those occurring on solid surfaces, where it is extremely difficult to express the concentration. But it is commonly accepted in these cases that the difficulty is in defining the concentration rather than being based on a new kind of variable.

It is, of course, quite possible to interpret these concentration and temperature variables in terms of various theories, but I will leave the discussion of such theories to the authors of other papers and adhere here to a discussion of some experimental observations with minimum reference to collision or activated complex theory as such.

Mechanism of Chemical Reactions

A major principle for the understanding of the mechanism of chemical reactions is committment to the idea that all mechanisms are possible, but that some mechanisms proceed more rapidly than others, and that normally the observed rates are determined by a single mechanism—that which is most rapid. Many systems are known in which simultaneous or parallel reactions occur, but many others can be adequately treated in terms of a single predominating mechanism.

In a typical predominating mechanism many steps may occur. These always, of course, involve the collision of certain reacting molecules and the formation of intermediate molecules. The intermediate molecules then continue to react in further steps of the reaction to produce the final products. Some reactions involve very complicated mechanisms and others relatively simple mechanisms, but in many cases the overall rate of the reaction is primarily determined by the rate of a single step known as the slow step of the reaction mechanism. When there is a single slow step the experimentally determined rate equation and the experimental dependence of the rate constant on absolute temperature turn out to be especially simple.

Finally, in the mechanisms of many chemical reactions the intermediate products are highly reactive and can exist only at small concentrations. In many cases, these concentrations build up as the reaction begins to a level which remains quite constant during the major course of the reaction. Such concentrations are said to experience a *steady state*. Substances having a steady state concentration are being formed and reacting at the same rate so that their net concentration at any time is constant.

Thus, one writes down various plausible mechanisms and compares the rate equation calculated from the assumed mechanism with the experimental one. Often only one mechanism is found which gives concurrence with rate and other (e.g., energetic) data. Such a mechanism is, then, assumed to be correct.

Equilibrium and Kinetics

Once the general mechanism of a reaction is understood, it is easy to demonstrate, by applying the principal of micro reversibility, that the equilibrium state involves a set of simultaneous reactions in which every step in the mechanism is proceeding in both directions at equal rates. It is also easy under these conditions to show the relationship of the rate expressions to the equation for the net reaction. The sum of all of the mechanistic steps must give the equation for the net reaction. Ordinarily the equation for the rate of reaction, if there is a single slow step, depends only on the concentration of the reactants in that slow step and on the absolute temperature of the system.

Applicability of Mechanistic Ideas in Early Chemistry

It is difficult to see why the ideas presented above which summarize most of the major points important in understanding rates and mechanisms of reaction cannot be presented at a much earlier stage than is now done. It further seems possible that presenting such ideas at an early stage would allow students to have a new comprehension of what actually occurs in chemical reactions and, thus, a much better understanding of the nature of chemicals and their interactions with one another. The problem remains to devise experimental methods of illustrating these ideas. It seems especially important to devise experiments which the students can themselves perform and from which these ideas become dramatically underlined. May I therefore suggest at least one experiment which seems to fulfill some of these criteria.

The "Blue Bottle" Experiment

Let us consider a chemical system which is very easily constructed and on which very simple experi-

The Cover

The "blue bottle" experiment fascinates everyone who tries it. Best of all, it teaches much. Here Karen Benker, a pre-med sophmore from Pomona College, and James Edwards, a junior chemistry major from Harvey Mudd College, intepret their summer research activities under NSF sponsored URP program at Harvey Mudd to inspect the unexpected.

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ments can be done by students with a minimal experience in chemistry.[1] I have used this experiment with students from the 7th grade through graduate school with considerable success at all levels. Even faculty members seem to be pleased with the observations and conclusions which can be made in connection with it. The system normally consists of a glass flask approximately half full of a clear colorless liquid with a rubber stopper in the top. Shaking the flask causes the liquid to turn blue. Upon standing the blue liquid reverts to its original colorless condition. Shaking initiates a further bluing, then de-bluing cycle. Students of all degrees of sophistication seem to enjoy suggesting interpretations of these observations. It is commonly suggested that there is a colored material on the stopper or that the increased contact with the glass on shaking causes the color change. These ideas are readily checked experimentally by up-ending the flask or by gently swirling it so that the liquid does cover the glass or touches the stopper. In neither case does the blue coloration appear.

Perhaps the most obvious change in the flask upon shaking is that the kinetic energy of the contents is increased. This leads to the idea that the rise in temperature causes the blue color with the subsequent loss in heat as the flask cools back to room temperature allowing the color to revert. Again this can be readily checked experimentally by warming the flask in one's hands and showing that the blue coloration does not occur.

The common suggestion at this point is that there are two layers which are mixed when the flask is shaken and then separate. This can be quickly checked by again up-ending the flask and noticing that the blue color disappears uniformly in the long cylindrical neck rather than rising or falling as would be true were there two layers which were separating. A similar suggestion is that shaking may mix any gas which is in the top of the flask with the liquid and that upon standing the gas separates from the solution again. This can also be experimentally checked just as the earlier two layer theory, since it is only a special case of it. Again the uniform disappearance of blue color throughout the flask indicates that this suggestion is not acceptable. Note that each suggestion fits all the observations made up to that point, but can be shown to be inadequate to fit further possible observations.

Once the idea that there may be a gas in the top of the flask arises, it becomes apparent that this may indeed be a reactant which does not later escape from the solution. Students quickly suggest various ways of checking this theory. Assuming that the gas pressure was originally atmospheric this pressure should have dropped and gentle removal of the stopper should show bubbles in the inside of the "liquid seal" around the stopper. It is wise to point out at this time that this may seriously affect the experiment by contaminating the contents of the flask with air. However, the experimental check does indeed show that the pressure is less than atmospheric and further shaking will again reduce the pressure below atmospheric. An even more clever way of checking the possibility that a gas is entering the liquid and causing the blue color is to observe the interface between gas and liquid. If the theory is correct there should be a thin blue layer where the mixing is continually occurring. Close examination shows this layer. The fact that the layer is not

[1] I found this experiment at the University of Wisconsin in 1954, but heard it was discovered at Cal Tech.

Clitheroe Royal Grammar School for Boys
York Street
Clitheroe, Lancashire
July 10, 1963

Dear Professor Campbell,

Following your lecture on "Chemical Study" at University College, London a week ago, and the few minutes conversation we had at the Middlesex Hospital Medical School, I yesterday gave a small group (seven) of my boys a flask with the methylene blue (caustic soda) glucose solution and asked them to deduce as much as they could about the chemistry of the system from what they could observe, without the use of any other reagents. They are all aged 18 and have just attempted "A" level chemistry. They were given no help or suggestions by me. One boy acted as "scribe" for the group and I enclose his rough notes (in red) and his report (in blue). The first side of the (blue) was done at the time of observation; the remainder was done after 24 hours thought by the boys. The train of reasoning is fairly clear (and it is interesting to note that at one time they thought the liquid had three reactive components X, Y, and Z).

Norman Thorpe
Senior Chemistry Master

(Red) notes from students

$$\text{Air} + \text{liquid} \xrightarrow{\text{fairly slow}} \text{Blue cpd} + (?)$$

$$(?) + \text{Something in liquid} \xrightarrow{\text{possibly fast or very slow}} X$$

$$X + \text{Blue cpd} \xrightarrow{\text{possibly very slow or fast}} \text{Liquid} + \underset{\text{colorless}}{\text{new cpd}}$$

$$\text{Air} + \text{Something in liquid} \xrightarrow{\text{overall}} \text{new cpd}$$

Liquid contains X and Y

$$\text{Gas} + X \xrightarrow{\text{fairly slow}} \text{blue cpd} + (?)$$

$$(?) + Y \rightarrow Z \text{ (another cpd)}$$

$$Z + \text{Blue cpd} \rightarrow X + \underset{\text{colorless}}{\text{new cpd}}$$

$$\text{Gas} + \underset{\text{catalyst}}{(1 \text{ component})} \rightarrow \text{blue cpd}$$

$$\text{Blue cpd} + 2 \text{ comp} \rightarrow \text{new cpd} + 1 \text{ component}$$

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thick coincides with the observation that the blue color disappears on standing. So, in the case of the surface layer, the blue color disappears as it diffuses into the bulk liquid. A further quick check can be run by replacing whatever gas is in the flask, normally air, by natural gas. Shaking the liquid with natural gas does not cause any blue coloration. Replacing the natural gas with air and repeating the shaking again causes the blue coloration which disappears on standing. One now has fairly conclusive evidence that some ingredient of air does indeed react with the liquid to form the blue solution.

By this time one will almost certainly have observed that the rate of the initial "bluing reaction," while not instantaneous, is quite rapid, occurring in a few seconds, whereas the disappearance of the blue color takes much longer depending on the conditions but approximating twenty seconds or so. This allows the tentative conclusion that there must be at least three reactions occurring in the flask. There is the solution of the gas in the liquid phase, followed by a reaction with something in the liquid to form the blue color, followed in turn by the reaction of the blue material to produce colorless products. We can tentatively represent this reaction mechanism (note that the student has arrived at this mechanism without any knowledge of the chemical ingredients of the flask and on the basis of very simple observations which can be made in any classroom) by the following scheme:

$$A(g) \rightarrow A(soln)$$
$$A(soln) + X \rightarrow B$$
$$B + Y \rightarrow \text{products}$$

Suggested mechanism 1

In this scheme A represents the original gas; B represents the blue material; X represents the reactant which converts the gas to the blue material, B; and Y represents the substance which reacts with B, the blue material, to give colorless products. It is interesting to note that essentially every group with whom I have discussed this experiment has arrived at this mechanism without very much prompting. The question now reads: Is the mechanism adequate to interpret all the experimental evidence? The answer is that it does indeed interpret all the experimental evidence observed so far by most of the people, but not all of the experimental observations which actually can be made. For example, perspicacious students will already have noticed that the length of time the solution remains blue depends on how long one shakes the flask. Very few will have specifically noted that it is also true that the intensity of the blue color is independent of how long the flask is shaken. These two bits of information, however, are readily observed and prove to be very important in continuing a study of the mechanism.

It is relatively easy to show, with an approximation to quantitative measurements, that the length of time the solution stays blue is directly proportional to the degree of shaking. One shake may cause blue color for ten seconds, two shakes for about twenty seconds, four shakes for about forty seconds and so on. Thus, the time the flask stays blue depends directly on the time of shaking. This is certainly consistent with the first step in the reaction scheme above in that one would expect more gas to dissolve if one shook longer. It is not readily consistent, however, with the second step. One might guess, if one increased the concentration of dissolved gas that the second step of the reaction would

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(Blue) notes from students

Examination of the contents of a flask

Shakes given to flask	Time to return to original color (sec)
1	10
2	15
3	20
4	25
5	30

On shaking, the solution turned blue, the intensity of the colour depending on the time shaken. The blue colour then faded back to the original colour.

The experiment was repeated in the dark. The times were the same showing that the solution is not light sensitive.

The apparent suspension in the liquid always remained white.

On removing the bung, air was heard to enter the flask. This suggests that some of the gas is permanently absorbed. This is confirmed by a permanent blue colouration which remains round the meniscus of the liquid. On tilting the flask a permanent ring appeared on the glass of the flask, corresponding to the meniscus of the liquid. On placing a glass stirring rod in the solution the blue ring formed around it. This suggests possibly that the glass is catalyzing the reaction.

The reasoning was then continued 24 hours later.

The first thought was that a reversible reaction was taking place. Since however the pressure is reduced inside the flask this theory is not altogether true. This reduction in pressure might be attributed to the gas absorbed on the surface (the blue colour shows this) but if the surface absorbs the gas, why does not the whole solution absorb gas. This leads us to think that the first reaction is one in which the gas is absorbed by the liquid. The equation for this step might be.

gas + first component of solution → blue compound

This is a fairly slow reaction. The blue compound then reacts with another component of the solution.

blue compound + second component of solution → new compound (colourless) + first component of solution

This is a very slow reaction.

The overall equation is

Gas + second component of solution → new compound

It would thus appear that one component of the solution is acting as a catalyst.

The slight blue colouration on the surface of the liquid is explained as follows: The gas reacts with the surface of the liquid to form the blue compound. The blue compound then reacts with the second component to form the new compound. Hence the second component near the surface of the liquid is all reacted and hence the blue colouration is permanent.

Conclusion

It would appear that the reaction taking place is of the general form

$$\underset{\text{catalyst}}{A + B} \rightarrow \underset{\text{addition compound}}{AB}$$

$$AB + C \rightarrow AC + \underset{\text{catalyst}}{B}$$

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proceed more rapidly and that increasing the initial concentration of dissolved gas by a factor of four would not cause the reaction to take four times as long. The time would certainly increase as there is more gas to remove, but it should not increase four times. Furthermore, the fact that the blue color lasts longer as the concentration of dissolved gas is increased is not directly consistent with the fact that, even though the concentration of dissolved gas may have increased, the intensity of the blue color, which apparently measures the concentration of an intermediate substance, does not increase. As a matter of fact, the constant level of the blue color would indicate that the concentration of this intermediate rather quickly reaches a steady state which is maintained throughout the body of the reaction, rather quickly dropping from a steady state value to zero as the de-bluing reaction nears completion.

How do we account for the lengthening of the time the system stays blue, while simultaneously accounting for the constant intensity of the blue color regardless of the concentration of dissolved gas?

At this point, students typically suggest many possible alternatives which can be explored experimentally. The weight and amount of experimental evidence is now so great that it is relatively easy to discard most of the theories which are presented. One theory which is not so readily discarded, however, is that X is actually a limiting reagent in the second step of the mechanism above. Perhaps increasing the concentration of dissolved gas cannot give any more blue color than can be formed from the limiting amount of ingredient X. It rather quickly follows from this hypothesis that if the blue color is to remain constant and yet be reacting in step three, X must be regenerated in step three and be a product. This is consistent with the observed fast rate of the second reaction and slow rate of the third. Thus, we might modify reaction three above to read:

$$B + Y \xrightarrow{\text{slow}} X$$

We now have a scheme which fits all the observations made so far. The constant level of blue color is reached because X is a limiting reagent which reacts rapidly with the dissolved gas forming the blue intermediate. The blue intermediate slowly reacts with Y regenerating X which quickly forms more blue intermediate by reacting with further dissolved gas. As the dissolved gas is completely used up, X remains in its colorless state and no more blue intermediate can be formed.

We now have a scheme which is consistent with all the observations which can be readily made merely by shaking the flask. However, we have not exhausted the possibilities which the system offers for exploration. For example, adding the three steps does not give a net reaction!

$$A(g) \xrightarrow{\text{fast}} A\,(soln)$$

$$A(soln) + X \xrightarrow{\text{fast}} B \qquad \text{Suggested mechanism 2}$$

$$B + Y \xrightarrow{\text{slow}} X$$

$$\text{Net: } A(g) + Y \longrightarrow ?$$

No product is indicated. This can be corrected by using scheme 3.

$$A(g) \xrightarrow{\text{fast}} A(soln)$$

$$A(soln) + X \xrightarrow{\text{fast}} B \qquad \text{Suggested mechanism 3}$$

$$B + Y \xrightarrow{\text{slow}} X + \text{products}$$

$$\text{Net: } A(g) + Y \rightarrow \text{products}$$

It is now possible to explore the effect of concentration on the rates of reaction. Since one does not know the chemical contents this can be done most readily by adding water to the flask. To the surprise of most students, the addition of water turns the contents of the flask blue. This surprise is rather quickly resolved when one remembers that there is dissolved air in water, and that it is this dissolved air which is almost certainly causing the blue. (As a matter of fact, this experiment turns out to be a rather good method for analyzing for dissolved air (oxygen) in waters and can be calibrated to give rather accurate and reproducible results.) Once the blue color caused by the added water has disappeared, one does indeed find that the rate of the de-bluing reaction has decreased, in fact it has decreased rather markedly. Another effect of decreasing the concentration of X is that the intensity of the blue color decreases, consistent with our mechanism. Thus, the concentration of X, and hence B, will have decreased by adding the water as well as the concentration of Y. The effect of decreasing the concentrations of B and Y, since they react in the slow step in the mechanism is that the overall mechanism slows down as observed. One might predict therefore that doubling the volume by adding an equal volume of water would decrease the rate of the slow reaction by a factor of four, since both B and Y decrease by a factor of 2 in concentration. Actually the rate drops more than this indicating that there is a complication of the mechanism not yet anticipated.

By this time, students will probably have noted that the solution is slippery. This indicates that it is probably basic. Since it is basic it may well be that the presence of base has some effect on the reaction mechanism. This is actually the final clue which is needed completely to unravel the mechanism because it is true that although hydroxide ion does not react in the rate determining step nor in the net reaction (as is true of B also), it is important in determining the overall rate of reaction. We thus find that the experimental rate equation for this reaction is

$$\frac{d[B]}{dt} = k[B]\,[Y]\,[OH^-]$$

Note that it is impossible, as is generally true, to guess the rate equation from the equation for the net reaction

$$A + Y \rightarrow \text{products}$$

Also note that the only chemical we have identified so far is hydroxide ion.

However, even without identifying the chemicals it is possible to study the effect of temperature on the rate of reaction by plotting the logarithm of the de-bluing time for a constant amount of dissolved gas as a

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function of the reciprocal of the absolute temperature, $1/T$. This is possible, because the rate of the slow step is independent of the concentration of oxygen and thus the time, t, it takes the total oxygen to disappear is directly related to the rate constant k. A straight line is obtained from a log t versus $(1/T)$ plot. (From this one can of course obtain the activation energy for the slow step.)

The actual system can be made up in a very rough fashion, but should contain approximately 20 g of sodium hydroxide, 20 g of glucose (reactant Y), and perhaps half a milliliter of 1% alcoholic methylene blue (reactant X) solution per liter of water. There is nothing very critical about these reactants and they need not be weighed out. It then becomes apparent that the system involves the oxidation of glucose by oxygen (reactant A) catalyzed by methylene blue.

Even without identifying the chemicals, it is possible for students to see that ingredient X is a catalyst for the reaction, since it is consumed and then regenerated in the reaction. Thus X appears in the rate equation but does not appear in the equation for the net reaction. This system is one of the few in which the intermediate molecule formed by the catalyst is actually visible. Thus, the system provides valuable support to any discussion of the nature of catalytic action.

The role of hydroxide ion is somewht more difficult to see and cannot be deciphered completely without a knowledge of the ingredients involved. The actual role of the hydroxide ion is to convert glucose, G (formerly called reactant Y), to the glucoside ion, G^-, in a rapidly reversible equilibrium. It is apparently the glucoside ion which is involved in the actual rate determining step.

$$\begin{array}{lll}
1. & G + OH^- \overset{\text{fast}}{\rightleftharpoons} G^- + H_2O & \\
2. & A(g) \xrightarrow{\text{fast}} A(soln) & \\
3. & A(soln) + X \xrightarrow{\text{fast}} B & \text{Suggested mechanism 4} \\
4. & B + G^- \xrightarrow{\text{slow}} X + \text{products} & \\
\hline
 & \text{Net: } G + A(g) \longrightarrow \text{products} &
\end{array}$$

The introduction of the equilibrium constant for the rapid reversible equilibrium allows one to show, however, that the rate can be expressed in terms of glucose concentration and hydroxide concentration, as we found experimentally to be the case.

Thus, for the slow step (and hence the whole mechanism)

$$\frac{d[B]}{dt} = k_4[B]\,[G^-]$$

where B is the oxidized (blue) form of methylene blue. But

$$K_{eq_1} = \frac{[G^-]}{[G]\,[OH^-]}$$

$$[G^-] = K_{eq_1}[G]\,[OH^-]$$

$$\frac{d[B]}{dt} = k_4 K_{eq_1}[G]\,[OH^-]\,[B] =$$

$$k[G]\,[OH^-]\,[B] = k\,[\text{glucose}]\,[OH^-]\,[\text{methylene blue}]$$

which agrees completely with the experimentally determined rate equation. Note the reaction is zero order in oxygen, the gas A, from the air.

It is now interesting to note that we have indeed introduced, with a very simple system, and very simple observations, most of the important ideas concerning the mechanism and rates of chemical reactions which it is normally considered a student entering graduate school should have. And we have done this at the level of a first course in chemistry. One can also point out that the reaction is susceptible to quantitative measurements in a laboratory. In terms of these quantitative measurements and an actual knowledge of the ingredients, it is quite possible for the student to gain great insight into the effect of changing concentrations or temperature on a reaction mechanism.

It is further profitable to point out to the student the analogy between the role of methylene blue in the oxidation of glucose in this system and that of hemoglobin in physiological systems where glucose is oxidized. Students prove to be quite interested also in the tie-in with the use of methylene blue as an antidote for carbon monoxide poisoning in the blood, and the mechanism of its action.

Kinetics—Early and Often

It is for reasons such as those presented above that the Chemical Education Material Study has made a serious effort to introduce the major ideas concerning rates of reaction and reaction mechanism in a clear and correct fashion in a first course in chemistry. It is for the same reason that we at Harvey Mudd College have introduced kinetic experiments at all levels from the freshman year on.

What is needed now are further reactions which illustrate, as clearly as the methylene blue, the various aspects of mechanisms. Particularly needed are some reactions whose rates can be readily measured, for which he rate equation can be directly determined, and for which it is obvious that the rate equation and the equation for the net reaction are unrelated in any simple fashion. The usual rate experiments (such as the iodine clock, hydrogen peroxide decomposition, inversion of sucrose) do not, unfortunately, meet these criteria. Even the reaction between silver ion and formate ion has the unfortunate property of possessing a rate equation which corresponds ostensibly to the equation for the net reaction. There are, of course, reactions known which do not have these drawbacks, but a larger number need to get into the literature of undergraduate experiments, and it is hoped that those knowing such experiments will see that this happens.

The field of reaction rates and mechanisms is far too important to be slighted in the future as it has been in the past. Experiments can be done, even in a first course in chemistry, which are intelligible to the student and which clearly point out the real effects of concentration and temperature. The complicated series of steps—with each step simple—which give the overall mechanism and the relationship of the reaction mechanism to the equilibrium state can also be deduced from experimental data. "Kinetics—Early and Often," ought to produce interesting results in the education of future chemists.

✦ ✦ ✦

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Richard M. Noyes
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Eugene

A Course in Kinetics Based on Elementary Processes

Chemical kinetics is of importance as a scientific discipline primarily because kinetic data are of major importance in elucidating the detailed mechanisms of chemical reactions and other molecular processes. These mechanisms are often fairly complex, but they are generally described in terms of *elementary processes* that are unimolecular, bimolecular, or (occasionally) termolecular and that take place in single steps.

During the past few years, I have been teaching a course on kinetics in solution, giving three lectures a week during the ten weeks of the spring term. The students are mostly seniors and first year graduate students who have had physical chemistry. The course has been aimed at giving the students an understanding of present theories of chemical reactions and of how experimental observations can be used to obtain information of mechanistic utility. The understanding of elementary processes has seemed to offer the best foundation on which to build the subsequent details.

The course first considers the theoretical treatment of elementary processes and the ways in which rates of these processes are affected by altering such factors as temperature, pressure, solvent, etc.

This detailed discussion of elementary processes provides a foundation for the subsequent consideration of the rates to be anticipated when reactions take place by complex combinations of such processes. The treatment is aided by keeping attention fixed on the instantaneous *rate* of reaction under specified conditions rather than considering integrated extents of reaction. Although integrated rate equations for simple empirical orders often play a considerable part in the teaching of kinetics, they are applicable to a fairly limited number of real reactions and give a rather restricted idea of the problems encountered by a practicing kineticist.

The course then leaves consideration of what the rate of reaction will be for different mechanisms and considers the reverse problem of gathering kinetic data and using them to draw mechanistic inferences. Although this arrangement delays consideration of the type of material with which an experimental kineticist actually deals, it provides a background that permits a more thorough discussion than is possible if treatment of data is introduced before the students appreciate the mechanistic complexities that can arise in practice.

The following outline does not develop the treatment in detail, but it will illustrate a few points and provide an idea of the type of argument. It is hoped that a book covering this material will be ready for publication in the not too distant future.

Introduction and Definitions

A chemical reaction can be represented by the balanced equation

$$aA + bB \rightarrow cC + dD \qquad (1)$$

where the capital letters are chemical species and the lower case letters are stoichiometric coefficients.

The *rate of reaction*, v, is defined to refer to the equation *as written*. Thus, for equation (1)

$$v = -\frac{1}{a}\frac{d[A]}{dt} = -\frac{1}{b}\frac{d[B]}{dt} = \frac{1}{c}\frac{d[C]}{dt} = \frac{1}{d}\frac{d[D]}{dt} \qquad (2)$$

For *some* reactions, the rate can be described over a range of concentrations by an equation of the form

$$v = k_{ex}[A]^{\alpha}[B]^{\beta}[C]^{\gamma}[D]^{\delta}[P]^{\pi} \qquad (3)$$

where the exponents are empirical *orders* that may be positive, negative, zero, integral, or non-integral and may or may not bear any relation to the stoichiometric coefficients of equation (1). The species P in equation 3 does not enter equation (1) at all. The *experimental rate constant*, k_{ex}, is an empirical quantity to be distinguished from the rate constants of elementary processes that are inferred from experimental data by assuming a mechanism for the overall process.

Any experimental rate constant should always refer to the v for a specified chemical equation like (1) and not to a multiple or fraction of that v. Failure of some polymer chemists to relate termination rate constants to the rates of the assumed elementary processes has seriously confused the literature of radical polymerization.

Theoretical Treatment of Elementary Processes

Collisional theories assuming equilibrium distributions. The usual kinetic equations can be derived from equilibrium radial distribution functions and rates of relative motion of molecules. The treatment can be extended to the situation in which the energy of several square terms can contribute to the activation needed.

Statistical thermodynamic theories. Populations of equilibrium energy states provide a basis for deriving the equations originally developed by Glasstone, Laidler and Eyring (*1*).

Theories for very fast reactions. Both collisional and statistical thermodynamic treatments assume that distributions of molecules in space satisfy functions derived for equilibrium. These assumptions fail for very reactive species in solution. The treatment employed has been developed elsewhere (*2*). If the course were not specifically restricted to solution kinetics, it might be appropriate at this point to discuss unimolec-

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ular gas reactions in which the equilibrium spatial distributions of internal energy levels are not maintained.

Effects of Controllable Factors on Rates of Elementary Processes

Concentration. Rates in ideal solutions can be treated easily. Statistical thermodynamic theories can be used to derive the equation

$$k = k_0 \, \gamma_A \gamma_B / \gamma^{\neq} \tag{4}$$

where k_0 is the rate constant in ideal solution and the γ's are activity coefficients if species A and B react to form a transition state.

Temperature. Standard equations are easily derivable for activation energy and related quantities.

Pressure. Volume of activation is defined and discussed.

Inert electrolyte. Debye-Hückel expressions for activity coefficients are used to predict effects of changes in ionic strength on rates of elementary processes involving ions.

Dielectric constant. Easily derivable equations predict effects of varying dielectric constant on ion-ion and dipole-dipole reactions. Students are warned that dielectric saturation effects make these equations of marginal value if macroscopic dielectric constants are employed. They are also warned against the dangers of using these equations to interpret effects when dielectric constants are changed by varying the relative amounts of solvent components.

Viscosity. This property has direct influence only on the rates of reactions so fast that equilibrium spatial distributions are not maintained.

Other solvent effects. Solvent media influence rates in many ways that are not yet satisfactorily characterized. Attempts have been made to define properties like nucleophilicity, ionizing power, etc. that have been proposed to characterize solvents.

Isotopic substitution. Rate of reaction may be affected by isotopic substitution of a species that is transferred during the elementary process. Usually smaller effects follow substitution elsewhere in the reactant or in the solvent. Rigorous treatment requires detailed understanding of molecular vibrations.

Molecular Structure. The subject is too broad for general treatment. The brief discussion in this course includes effects of substituents on rates of reactions in aromatic systems.

Kinetics of Consecutive Processes

A consecutive process is defined to be of the form

$$\begin{aligned} A + R_1 &\rightleftarrows I_1 + P_1 \\ I_1 + R_1 &\rightleftarrows I_2 + P_2 \\ &\cdots \\ I_{j-1} + R_j &\rightleftarrows I_j + P_j \\ &\cdots \\ I_{n-1} + R_n &\rightleftarrows Q + P_n \end{aligned} \tag{5}$$

where A and the R's are reactants, Q and the P's are products, and the I's are intermediates. The species A, Q, and each of the I's must be chemically distinct from each other and from all of the other species in these equations. If any species occurs as both R and P, it does so only once for each.

Steps are said to be locally equilibrated when their forward and reverse rates are almost equal and to be irreversible when the reverse rate is negligible compared to the forward rate. A step pre-determines subsequent steps if those steps are virtually sure to follow the occurrence of the pre-determining step.

Conditions are then developed for application of the rate-determining step approximation and of the uniform flux sequence of Christiansen (*3*). When neither approximation is applicable, the reaction can sometimes be separated into sequences for which these approximations are valid. The argument is presented in detail in a forthcoming paper (*4*).

Kinetics of Parallel Processes

Parallel processes provide different mechanisms by which the same reactants can go to the same products. A typical example is the oxidation of oxalate ion by manganese(III); transition states having empirical formulas $MnC_2O_4^+$, $Mn(C_2O_4)_2^-$, and $Mn(C_2O_4)_3^{3-}$ can all contribute to the reaction. The total rate in such a system is the sum of the rates due to the individual parallel processes.

Kinetics of Competitive Processes

Competitive processes occur when the same species may react in two or more different ways giving different products. Competition may be for different positions in the same molecule as in reactions of substituted benzene derivatives, it may involve two species attacking the same initial reactant so that the rate of disappearance of the reactant is the sum of the rates of the two reactions, or it may involve competition for an unstable intermediate so that changing concentrations of competing reagents affect the final composition of the products but not the overall rate of reaction. The discussion of competitive processes provides a good point for presenting the distinction between kinetic and thermodynamic control of reaction product composition.

Kinetics of Repetitive Processes

Repetitive processes are those in which an intermediate can undergo a sequence in which the intermediate is regenerated. This sequence is usually in competition with some other reaction that consumes the intermediate. Many examples involve free radical chains.

Topics discussed include effects on the overall kinetics from change in radicals undergoing termination and competition of termination reactions that are first and second order in radicals.

Branched chain reactions are discussed briefly.

Kinetics of Catalytic Processes

In principle, catalytic processes usually belong in the class of consecutive processes already considered. They offer the interesting kinetic feature that some species that appears as both R and P in equation (5) is usually in much smaller concentration than are the chief reacting species. The discussion offers examples, distinguishes specific and general acid catalysis, and mentions a little about enzymes.

Autocatalysis presents a special problem because catalyst is produced as the catalyzed reaction proceeds.

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Kinetics of Induced Reactions

A slow reaction having a favorable free energy change can be induced to go more rapidly by the simultaneous occurrence of another irreversible reaction in the same system. Examples discussed include some of the chemistry of chromium and manganese and the use of initiators in free radical polymerization.

Kinetics of Reversible Reactions

When the final position of equilibrium involves measurable concentrations of the initial reactants, the kinetics of forward and reverse processes are related. The relationship does not permit the kinetics in one direction to be uniquely determined from the kinetics in the other, but certain conclusions can be drawn.

The principle of microscopic reversibility also provides a useful touchstone for rejecting certain mechanisms that would otherwise appear plausible.

Experimental Techniques

Conventional kinetic studies in batch systems require temperature control, measurement of time, and a precise and rapid analytical method. When the time scale gets shorter than a few seconds, techniques can involve mixing in continuous flow, stopped flow, or stirred reactors. When the times of interest become too short even for mixing techniques, a system initially at equilibrium can be perturbed by a periodic method such as ultrasonic sound absorption or by a discontinuous change such as temperature jump or flash photolysis (5).

Mathematical Treatment of Data

Since most experimental techniques measure concentrations at specific times, and since rate of reaction is a derivative quantity, many mathematical treatments involve integration of rate equations for comparison with experiment. Other techniques involve getting derivatives of continuous curves approximating experimental observations. Some specific methods have also been developed.

Mechanistic Interpretation of Kinetic Data

Information from concentration dependence. If all subsidiary equilibria are known and if a single rate determining step exists, the concentration dependence can be used to determine the empirical formula of the transition state for that step. Separate terms in the numerator of the rate expression and increase of apparent order with increasing concentration of reactant indicate parallel mechanistic paths for obtaining product. Separate terms in the denominator and decrease of apparent order with increasing concentration of reactant indicate contributions from consecutive steps or unidentified intermediates formed in significant concentration. Fractional orders frequently but not invariably accompany radical chain processes.

Much of modern kinetic work is concerned with demonstrating the existence of intermediates and determining their properties. Although unequivocal evidence for an intermediate can often be obtained by some competitive technique, lack of evidence can only shorten the permissible lifetime of the intermediate but cannot prove its non-existence.

Information from temperature dependence. Activation energies and similar quantities can often be combined with thermochemical information such as bond energies to draw useful mechanistic conclusions.

Information from other factors. Many factors such as pressure, ionic strength, dielectric constant, etc. have been shown above to influence rates of elementary processes. When the rate of a real process is found to be influenced by these factors, mechanistic inferences can often be drawn. They must be drawn carefully as illustrated by the fact that different investigators have reported (apparently correctly in each case) that increasing ionic strength strongly accelerates, strongly decelerates, or scarcely affects the rate of decomposition of oxalate complexes of manganese(III) (6).

Literature Cited

(1) Glasstone, S., Laidler, K. J., and Eyring, H., "The Theory of Rate Processes," McGraw-Hill Book Co., New York, 1941, p. 185ff.
(2) Noyes, R. M., *Prog. Reaction Kinetics*, 1, 129 (1961).
(3) Christiansen, J. A., *Z. physik. Chem.*, 28B, 303 (1935).
(4) Noyes, R. M., *Prog. Reaction Kinetics*, 2, (in press).
(5) Eigen, M., "Technique of Organic Chemistry, Vol. VIII, Part II, 2nd ed., Investigation of Rates and Mechanisms of Reactions, Very Fast Reactions in Solution," edited by S. L. Friess, E. S. Lewis, and A. Weissberger, Interscience Publishers, New York, 1963, p. 895ff.
(6) Malcolm, J. M., and Noyes, R. M., *J. Am. Chem. Soc.*, 74, 2769 (1952).

1963 Chemistry Listing: Selected Science Books for Secondary Schools

This guide for librarians and science teachers was prepared by the Connecticut Science Teachers Association. The titles chosen are largely of recent copyright and are considered of value for reference and supplementary reading by student and teacher. The advent of new programs in secondary school chemistry (CBA and CHEMS) and the growing prevalence of the advanced-placement chemistry course have received special consideration by the Committee in the selection of titles. Listing is by author and title, coded for suggested use and with brief commentary. Available for $0.25 from CSTA Bibliography Committee, Central Connecticut State College, New Britain, Conn.

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Chemical Kinetics in Laboratory and Classroom

Chemical kinetics is a subject of such importance to chemistry that the teaching of it must of necessity permeate the entire curriculum. The student is introduced to rates of reaction in freshman chemistry (or better yet, in high school chemistry). The framework of kinetics is set forth in the usual physical chemistry course. Examples and more elaborate developments are presented in advanced courses on inorganic and organic chemistry. In spite of the ubiquitous nature of this subject, many institutions have found it advisable to supplement the above fare with a further more-or-less intensive helping of kinetics for the undergraduate. In the following I will present the experience at Berkeley in teaching selected aspects of kinetics in an undergraduate laboratory course on inorganic chemistry. Although the examples are chosen from inorganic systems, the methods are generally applicable.

The course consists of a one hour lecture once a week and two laboratory periods of 3 hours each. By no means is the course devoted entirely to kinetics: perhaps 75% of the lectures deal with kinetic problems but only about one-third of the laboratory work, the remainder being concerned with equilibria, stoichiometry, etc. The chief architect of this course was Professor William C. Bray to whom must go the major credit for its successes. Others who have participated in making substantial modifications are Professors Rollefson, Powell, and myself. Professor Powell particularly has influenced the lecture treatment.

The course content concerned with kinetics has practical objectives. The aim is to give the student a working knowledge which will enable him to plan, carry out, and interpret measurements on rates of reaction. It is hoped that the student will develop a clear understanding of kinetics and will learn to apply his knowledge readily whenever he deals with a rate of reaction.

The lectures start with various stratagems for finding the rate law from experimental data. Important in this connection is the proper planning of experiments so that the data can be readly and reliably applied to establishing the rate law. The technique of "flooding" is emphasized because of the simplification it ordinarily produces by reducing the rate equation to a power dependence on a single concentration. The student is shown how the complete rate law may be obtained even though the concentration of the same substance is always kept small in the flooding procedure—a point which invariably gives some difficulty.

For cases where flooding is possible, concentration dependences and rate constants may be obtained readily by (*a*) substitution into the integrated rate law, (*b*) plotting in such a fashion as to yield a straight line (e.g., log (conc.) versus time for a first order reaction), or (*c*) by a Powell plot.[1] Except for refined calculations, it is advantageous to use a plotting method so that all the data are displayed simultaneously. The importance of having an estimate of the experimental uncertainty of the data is stressed, particularly where one plots logarithms or reciprocals of measured quantities.

When flooding is not convenient experimentally, the rate equation is not so readily integrated and the correct rate law can usually be found more easily by use of the differential form. The student is given practice in this procedure by plotting concentration-versus-time data, taking the slopes at intervals, and substituting these values into various assumed rate equations in the differential form until the correct one is found.

Laboratory Experiments

The planning and interpretation discussed in the lectures is put into practice in the laboratory when the student determines the rate law for the following net reaction:

$$H_2O_2 + 3I^- + 2H^+ = I_3^- + 2H_2O$$

The reaction takes place in a few minutes at room temperature with reasonable concentrations and is accompanied by a readily observable color change. The student is instructed to carry out the measurements by preparing in a test tube a standard triiodide solution corresponding to a small fraction reaction of the peroxide, say 10%. He then observes by eye the time for the reaction to proceed this far in another test tube of the same size. By varying the concentrations of the reactants one by one he can find the order with respect to each and thus the form of the rate law.

It is obvious that the method of measurement used here is crude, yet it is intentionally so. The time for a certain per cent reaction may be obtained much more precisely by adding the appropriate amount of thiosulfate at the start of the experiment and observing the sudden appearance of the triiodide color when the H_2O_2-I^- reaction has produced just sufficient triiodide to consume all of the thiosulfate. Our experience in using this latter procedure, however, was that the student centered his attention on the method of detection rather than the rate of reaction under study.

Presented as part of the Symposium on Kinetics in the Undergraduate Curriculum before the Division of Chemical Education at the 144th Meeting of the American Chemical Society, Los Angeles, California, April, 1963.

[1] Frost, A. A., and Pearson, R. G., "Kinetics and Mechanism," John Wiley and Son, New York, 1961, p. 14.

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The visual detection of a certain extent of reaction has additional advantages. The student learns that simple observations and particularly visual observations are important and can lead to useful conclusions. In the present case, after a few trials, he has little difficulty in obtaining times for reaction within ±15% of the correct values.

In interpreting the data the differential form of the rate law is used. A doubling of the iodide concentration leads to a halving of the reaction time for the same standard. It is desirable to give the student experience in handling the differential form since he is not apt to get it in the physical chemistry laboratory and because the physical meaning of the mathematical expression is more easily grasped with the differential than with the integrated form of the rate law. The student must think clearly about what to expect when he doubles his initial peroxide concentration but also doubles his blank to correspond to the same fraction reacted.

The student is instructed to determine the hydrogen ion dependence from *ca.* 10^{-5} to *ca.* $0.5M$ H^+. Since the rate law is[2]

$$+\frac{d[I_3^-]}{dt} = k_1[H_2O_2][I^-] + k_2[H_2O_2][I^-][H^+]$$

he undergoes the rewarding experience of interpreting an apparent non-integral concentration dependence.

As an extra experiment the student may elect to measure a heat and entropy of activation.

In another laboratory experiment the student learns something of the nature of steady states through the study of the catalytic decomposition of hydrogen peroxide by the Br^--Br_2 couple.[3] The two reactions bringing about the steady state are

$$2Br^- + H_2O_2 + 2H^+ = Br_2 + 2H_2O$$

$$Br_2 + H_2O_2 = 2Br^- + 2H^+ + O_2$$

The net reaction at the steady state, where the above two rates of reaction are equal, is the sum, i.e.

$$2H_2O_2 = 2H_2O + O_2$$

In qualitative experiments the student first demonstrates that a steady state is approached from either side, i.e., by starting with peroxide and bromide or with peroxide and bromine, both in acidic solution. In quantitative experiments he determines the value of the steady state quotient R which has the form

$$R = \frac{[Br_2]}{[H^+]^2[Br^-]^2}$$

as a consequence of the rate laws for the two reactions. The distinctions between a steady state and an equilibrium are discussed.

In many minor experiments in the laboratory the student encounters reactions which do not occur in a reasonable length of time. He is faced with the two possibilities: the reaction is slow or the equilibrium is unfavorable. In most cases he can decide about the position of the equilibrium through available data on equilibrium constants, free energies, emf's, or heats and entropies.

[2] See for example Liebhafsky, M. A. and Mohammad, A., *J. Am. Chem. Soc.*, **55**, 3977 (1933).

[3] Bray, W. C. and Livingston, R. S., *J. Am. Chem. Soc.*, **50**, 1654 (1928); **45**, 1251, 2048 (1923). Livingston, R. S., *J. Am. Chem. Soc.*, **48**, 53 (1926).

Topics Discussed in Lectures

A substantial section of the lecture material considers what can be deduced about mechanisms from rate laws—and what cannot be deduced. For a simple, single-term rate law the formula of the activated complex corresponds to the stoichiometry of the rate law, plus or minus solvent, provided only a single activated complex controls the rate.[4] From the form alone of such a rate law the existence of equilibria before the rate determining step can be concluded only if one or more of the concentrations has a negative or fractional exponent. Generally the conclusion that there is an equilibrium before the rate determining step does not lead to an unambiguous identification of that equilibrium. The above statements depend on the assumption that a single activated complex controls the rate. When more than one activated complex is involved the interpretation is more complicated.

Basically two complex forms of rate law exist: the multiple term numerator and the multiple term denominator. When concentrations are expressed in terms of actual species present, these two forms have the simple physical interpretations of parallel reactions for the first and non-productive step(s) competing with a productive step for the second. The student is given practice in postulating mechanisms for such cases. The idea of the steady state approximation enters here. Stress is laid on the exact nature of the approximation and the fact that it does not lead to a constant concentration of intermediate.

Chain reactions are considered briefly. Rate laws are derived from mechanisms but the more difficult task of finding mechanisms from rate laws is only mentioned.

At this point the student is assigned a paper in the literature and is required to write a brief criticism of it. The paper chosen contains an unusual number of errors, both fundamental and trivial. For the good students this is a valuable experience in pitting their intellect against that of the authors. For all of the students it serves as an invaluable demonstration of the care which one must exercise in accepting conclusions even though they are in printed form.

The deduction of the reverse rate law from a combination of the forward rate law with the equilibrium expression is carried out along with a discussion of the principle of microscopic reversibility. The ambiguity in the derived rate law is considered and it is shown how the experimental determination of a single parameter for the reverse reaction, such as the exponent of one concentration or the $\Delta H\ddagger$ for the reverse reaction, suffices to remove the ambiguity. It is also pointed out that the removal of this ambiguity gives additional mechanistic information, i.e., the number of reactant molecules disappearing for each activated complex.

Electrolyte effects are considered briefly in terms of the Brønsted equation derived from activated complex theory. Reference is made to useful approximations for estimating activity coefficients of ions outside of the Debye-Hückel region and attention is paid to the uncertainty in such estimates.

[4] There is an unimportant exception to this rule which may occur when two or more intermediates have concentrations proportional to each other or to some power of each other.

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A discussion is given of the maximum rate possible for a bimolecular reaction in a solvent such as water. The available experimental results are shown to be in substantial agreement with these expectations. The concept of a limiting rate is useful in proving that certain mechanisms cannot possibly account for observed rates, and examples are considered.

It is shown how the rates of dissociation of acids and hydrogen and hydroxide ions ordinarily react with bases and acids at approximately diffusion-controlled rates. Combining these estimated rates with the equilibrium constant for dissociation one has an estimate of the rate constant for dissociation. It is instructive to the student to learn how slowly water dissociates.

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A Laboratory Program in Chemical Kinetics

Three years ago a new course entitled chemical kinetics was offered for the first time at Carleton College. The course was offered in the senior year to students who had already taken courses in organic chemistry, analytical chemistry, and thermodynamics. It is the second in a series of three, one-term physical chemistry courses which replaces a one year physical chemistry course. The laboratory work in this course was designed to be something of a bridge between the student-planned research of graduate school and the teacher-planned laboratory exercises typical of much undergraduate laboratory work. It was felt that students should be forced to assume much of the responsibility for planning as well as executing their experiments. Students should be challenged by the task of interpreting raw data without having a handy instruction sheet to tell them what equation to use and when to use it. Above all it was hoped that somehow during the course every student would feel the thrill that is often accompanied by the exclamation "A ha! I have discovered something." It was also expected that the laboratory work would reinforce the ideas developed in the lecture part of the course and provide an opportunity for the students to become familiar with a wide variety of chemical instruments.

The detailed plans for the laboratory work were based on some assumptions or intuitive rules of thumb. Since real experimentation was to be encouraged, ample time for mistakes or rambles down blind alleys should be provided. Unless a student has the freedom to make mistakes, he really has no freedom at all. This concept means that an average experiment will require at least two afternoons of work. In order to ease the shock of weaning the students from teacher planned exercises, a gradual transition should be made starting with fairly detailed instructions and ending with assignments having almost no specific instructions. The emphasis in each experiment should be placed on the discovery of the form of the rate law and its mechanistic implications, rather than just the determination of the numerical value of a rate constant. This means that a student never knows the form of the rate law for a given reaction before he begins experimenting with the reaction. This approach was expected to provide an opportunity for students to learn general methods of data analysis suitable for a variety of kinetic situations as well as to stimulate student interest.

Presented as part of the Symposium on Kinetics in the Undergraduate Curriculum before the Division of Chemical Education at the 144th Meeting of the American Chemical Society, Los Angeles, California, April, 1963.

Assigned Experiments

The first reaction studied in the course is the familiar alkaline hydrolysis of ethyl acetate.

$$CH_3COOC_2H_5 + OH^- = CH_3COO^- + C_2H_5OH$$

Considerable help in the way of detailed instruction is provided the student in this experiment. For example it is suggested that he first check to see if the reaction follows a one term rate law of the form

$$\frac{d[OH^-]}{dt} = k[OH^-]^m[EtAc]^n$$

He is further instructed to run his first experiment with stoichiometric quantities of reactants so the rate law will be simplified to the form

$$\frac{d[OH^-]}{dt} = k[OH^-]^{m+n}$$

To make life really easy for the student, a detailed procedure for carrying out this first, stiochiometric

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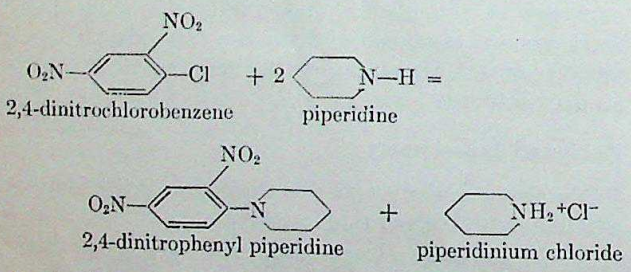
experiment is provided. This procedure includes the amounts and concentrations of all reagents, sampling procedures, and the analytical method to be used in determining the hydroxide concentration in each aliquot.

There are still a few details left for the student to work out. He must decide what mathematical technique should be used to analyze the results of the stoichiometric experiment and so determine k and the quantity $m + n$. He might decide to use the technique developed by Powell of plotting per cent reaction versus log t (*1*), or he might check each of the integrated forms of the rate law graphically or analytically. The student is also asked to design and carry out a second experiment to allow the determination of m and n individually. This might be done by changing the concentration of only one of the reactants in the second experiment and comparing the initial rates of the first and second experiments. Or, an experiment could be designed in which the general second order integrated rate law could be used to analyze the data. The actual experimental procedure to be followed in the second reaction need only be slightly different from that used in the first experiment.

Two afternoons of laboratory work are required by a team of two students for the completion of this problem. Stock solutions of all reagents as well as standardized solutions of all analytical reagents are provided for the experiment. This policy is followed as far as is possible for all experiments in the course.

The hydrolysis of ethyl acetate is an appropriate reaction to begin the course for several reasons. It is simple and straightforward from a kinetic point of view, the analytical procedure used to follow the reaction is simple and familiar, and the species involved in the reaction are familiar. These considerations of familiarity allow the student to concentrate on understanding the kinetic techniques and ideas.

The second experiment is a study of the following reaction (*2*).



Again the student is given a considerable amount of help in planning the experiment, but a little more effort is demanded from him than in the ethyl acetate experiment. It is suggested to the student that the technique of flooding be used in his first experiment with the initial concentration of the piperidine much greater than twice the initial concentration of the 2,4-dinitrochlorobenzene. If the reaction can be described by a one term rate law, its rate law should have the form

$$\text{rate} = k\,[\text{2,4-dinitrochlorobenzene}]^m[\text{piperidine}]^n$$

which simplifies under conditions of excess piperidine to

$$\text{rate} = k_{ps}\,[\text{2,4-dinitrochlorobenzene}]^m$$

where k_{ps} is a pseudo rate constant related to the true rate constant by the following equation.

$$k_{ps} = k\,[\text{piperidine}]^n$$

Complete details for carrying out an experiment under conditions of excess piperidine are provided for the student. These instructions provide for a spectrophotometric determination of 2,4-dinitrophenylpiperidine in quenched aliquots.

As in the hydrolysis experiment the student is asked to decide what mathematical approach should be used to analyze the data from the experiment with the excess piperidine. He is then asked to design and conduct a second experiment which will allow the determination of the order with respect to the piperidine. Most students choose one of three approaches. Some attempt to carry out a reaction with the 2,4-dinitrochlorobenzene in excess and they immediately run into trouble because it is not soluble enough in the ethanol used as the solvent for the reaction. Others choose to use stoichiometric conditions and have trouble with too intense coloration of the product and sometimes too rapid a reaction. The best choice is to keep the piperidine in excess but change its initial concentration from that of the first experiment. This allows determination of a second pseudo rate constant, k'_{ps}. The following two simultaneous equations can be set up and solved for k and n.

$$k_{ps} = k[\text{piperidine}]^n$$
$$k'_{ps} = k[\text{piperidine}]'^n$$

The students' woes are not over. He is now asked to design and carry out an experiment to verify the results he has obtained so far; but this is to be done by taking aliquots, quenching, and determining the chloride concentration in each aliquot by a potentiometric titration. In order to get enough chloride for accurate analysis, completely different conditions must be used than were used in the first part of the experiment.

As a final task, the student is asked to design and carry out an experiment which will allow the calculation of $\Delta H\ddagger$ and $\Delta S\ddagger$.

In the interpretation of his results the student is asked to propose a mechanism which would account for the fact that the rate law is first order in each reactant while the stoichiometry of the equation calls for two molecules of piperidine to react with each molecule of 2,4-dinitrochlorobenzene.

This reaction is highly satisfactory from a number of points of view. It allows the very important technique of flooding to be used, it can be studied by a variety of analytical methods, it illustrates that the form of the rate law cannot be predicted from the stoichiometry, and it goes to completion. Besides all of this, it works well.

As an exercise in thinking and as a relief from the demands of careful, quantitative experimental work, the students have usually been asked to spend an afternoon with test tubes and graduated cylinders studying the iodate-hydrogen sulfite clock reaction (*3*). The reaction is carried out in acid solution in the presence of starch with an excess of iodate. It proceeds according to the following equation until all of the hydrogen sulfite has reacted.

$$IO_3^- + 3HSO_3^- = I^- + 3SO_4^{2-} + 3H^+$$

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After all the hydrogen sulfite has reacted, I^0 appears and is detected by the abrupt appearance of a blue-black color caused by the formation of the starch-iodine complex. Students never cease to be amazed to discover that increasing the hydrogen sulfite concentration decreases the time required for all of the hydrogen sulfite to react. The solution to this riddle makes an excellent problem for seniors, but the existence of the riddle makes this a poor reaction for freshman chemistry demonstrations.

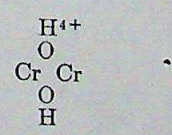
After the clock reaction, different experiments have been done during each of the three years that the course has been offered. These experiments have included the following: a polarographic study of the hydrolysis of hexachloroantimonate(V) (*4*), a conductometric study of the alkaline hydrolysis of methylbenzoate and related compounds as an illustration of the use of the Hammett equation (*5*), the determination and interpretation of $\Delta H\ddagger$ and $\Delta S\ddagger$ for the reaction of bromoacetate and thiosulfate (*6*), and a test of the Brønsted equation for the prediction of ionic strength effects on the oxidation of hexaaquochromium(III) by peroxydisulfate (*7*). Not more than one or two of these experiments have been done by any single pair of students. It is hoped that in future years experiments can be developed which will deal with very fast reactions, gas phase reactions, and the use of radioactive tracer techniques.

Independent Work

The last part of the course is used for an independent study in which the students must plan all aspects of the work with very little help from the instructor. Each team of students is expected to choose a general experimental approach, decide on the analytical methods to be used, work out the proper concentration range so that the reaction is neither too fast nor too slow, and take care of all the other details which must be considered in planning a kinetic investigation. The study of the reaction of hydrogen peroxide and iodide in acid solution is an excellent subject for such work (*8*).

$$2H^+ + H_2O_2 + 3I^- = I_3^- + 2H_2O$$

The kinetics of this reaction can be studied in several ways using different analytical procedures. The rate law for the reaction has two terms so it is sufficiently puzzling to provide a challenge to the best of students. As an alternative to working on this problem students have sometimes worked on unsolved problems of their own choosing. These problems have usually developed from suggestions made by the instructor. They have ranged from an attempt to determine the mechanism for the decomposition of



in acid solution to the development of an experiment suitable for use in the freshman chemistry course based on the reduction of thiocyanatoiron(III) by tin(II). Care must be exercised in choosing problems for this kind of independent work. It is not necessary that the problem be completely worked out in this period of time, and indeed, it is not very often that this is done. It is important that the students do not become so bogged down with severe analytical problems, or hopelessly complex kinetic situations that no progress at all can be made toward discovering the rate law.

Student reaction to this course has been most gratifying, especially after the course has been completed. None of the students who have taken the course have avoided periods of frustration and exhaustion, but on the other hand, all of them have experienced moments of elation when all the pieces of the puzzle seemed to fit together. The achievement of being able to plan an experiment and work out the problems involved in its execution gave almost all of the students a feeling of real satisfaction.

The basic purpose of this laboratory program is to provide an opportunity for advanced chemistry students to become involved with the planning and interpretation of experimental work. Chemical kinetics is a particularly appropriate setting for such work for two reasons. First, the experimental work can be conducted without the use of difficult or time consuming experimental methods. Secondly, a minimal theoretical background is required to design and interpret the kind of kinetic experiments discussed here. When a student is asked to do laboratory work requiring considerable theoretical background or difficult experimental techniques, he has all he can do to understand his instructions much less plan new work in the field himself.

In summary, the laboratory program described here consists of a series of four or five experiments. In all experiments the student is faced with the problem of determining a rate law. In the first experiment, the hydrolysis of ethyl acetate, the student does only a small amount of the planning. In the second experiment, the reaction of piperidine and 2,4-dinitrochlorobenzene, he must do more planning; and finally, he is asked to study the kinetics of a reaction with no help at all. The experiments done in the course are not distinctive and are undoubtably done at many colleges. We feel that the involvement of the students in experimental design is somewhat distinctive and has resulted in a stimulating and interesting course.

Acknowledgement

Dr. William Child of Carleton College has made important contributions in the development of this course. He taught the course during the past year and designed several of the experiments.

Literature Cited

(1) Frost, Arthur A., and Pearson, Ralph G., "Kinetics and Mechanism," 2nd edition, John Wiley and Sons, Inc., New York, 1961, p. 14.
(2) Bunnett, J. F., and Crockford, H. D., J. Chem. Educ., 33, 552 (1956).
(3) Sorum, C. H., Charlton, F. S., Neptune, J. A., and Edwards, John O., *J. Am. Chem. Soc.*, 74, 219 (1952).
(4) Neumann, H. M., and Ramette, R. W., *J. Am. Chem. Soc.*, 78, 1848 (1956).
(5) Leisten, A. J., J. Chem. Educ., 38, 302 (1961).
(6) Yost, D. M., *J. Am. Chem. Soc.*, 48, 152 (1926).
(7) La Mer, W. K., *J. Am. Chem. Soc.*, 51, 3341 (1929).
(8) Liebhafsky, H. A., and Mohammed, A., *J. Am. Chem. Soc.*, 55, 3977 (1933).

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Absorption, Dispersion, Circular Dichroism, and Rotary Dispersion

One of the great accomplishments of science has been to demonstrate the underlying unity among various superficially different phenomena. One of the aims of teaching science should be to point out this unity whenever possible. The purpose of this paper is to indicate a neglected opportunity to do just this in elementary physical chemistry. The topics to be discussed are light absorption, dispersion, circular dichroism, and rotatory dispersion. These very closely related phenomena are all of importance in chemistry and yet, to the writer's knowledge, no elementary physical chemistry texts discuss them as a unified topic. This is especially unfortunate since on a phenomenological level it could be very easily done.

Absorption and Dispersion

Let us first consider the relationships between ordinary light absorption and dispersion[1] measurements. If the dispersion curve and absorption spectrum of a compound with a weak absorption band are compared, there will be no apparent relationship between them. For example Figure 1 shows such curves for cyclohexanone which has a very weak absorption band near 290 mμ (*1*). The dispersion curve rises monotonically on going to shorter wavelengths, apparently even in the vicinity of the absorption band.

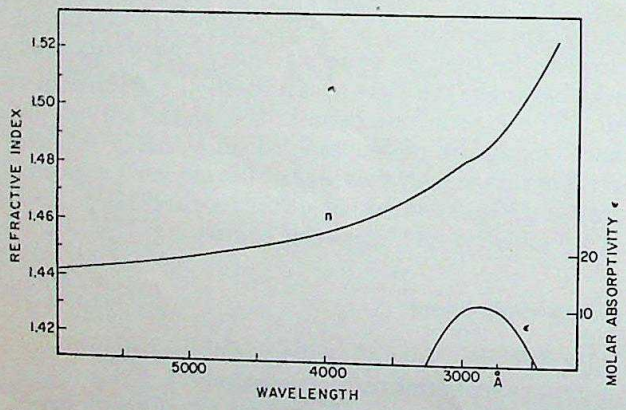

Figure 1. Absorption and dispersion curves for cyclohexanone. Redrawn from Allsopp (*1*).

On the other hand if the same type of curves are compared for compounds having a strong absorption band, there is clearly a relationship. For example Figure 2 shows the absorption and dispersion curves for the strongly absorbing permanganate ion (*2*).

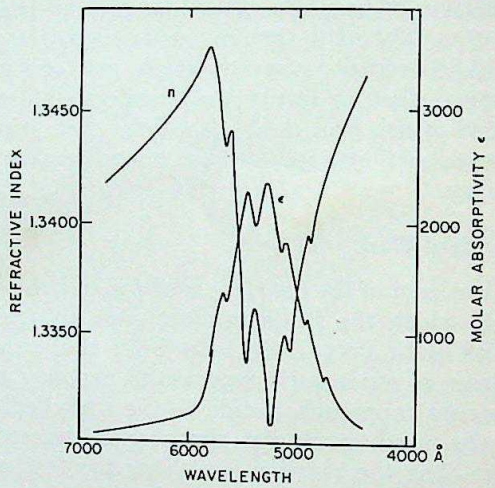

Figure 2. Absorption and dispersion curves for aqueous potassium permanganate. Redrawn from Taylor and Glover (*2*).

This is an example of a general phenomenon which is well understood in both classical and wave mechanical terms (*3*). Figure 3 shows the behavior to be expected with the idealization that the index of refraction is determined by a single absorption, and that the conversion of radiant energy to heat follows a simple law. There are several points to be noted in this figure. First, the dispersion curve rises on going to shorter wavelengths, i.e., this part of it is a "normal" dispersion curve. Second, in the absorbing region the dispersion curve falls on going toward shorter wavelengths, and therefore, this portion of it is called an "anomalous" dispersion curve. Third, in the middle of the absorption band the refractive index becomes equal to its value in a vacuum and at still shorter wavelengths it can actually become less than unity.[2]

A very important aspect of this relationship between absorption and dispersion is that a strong absorption band will always give rise to a large anomaleus dispersion and a weak absorption a small anomaly. This

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[1] A graph of refractive index versus wavelength is called a dispersion curve, because it indicates how light of various wave lengths would be dispersed by a prism of the material being studied.

[2] This means that the velocity of light is greater than in a vacuum which is an apparent violation of relativity theory; but this velocity is the *phase* velocity, whereas relativity theory is concerned with the group velocity.

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means then that in the case of the data shown in Figure 1, if extremely accurate measurements were made, a small wiggle should be found in the dispersion curve near the weak absorption band. (There is actually a small break in Allsopp's data but it is not easily seen on the scale used in the present drawing.)

As would be expected, it is possible to develop theoretical relationships between these curves and thus to calculate one curve from the other. These are the Kronig-Kramers equations. It is also possible to discuss these relationships very nicely qualitatively or quantitatively in terms of a simple damped harmonic oscillator model. In order not to detract from the basic simplicity of the phenomenological relations, a further discussion of the physical origin of the absorption-dispersion relationships, together with pertinent references, is included in the appendix.

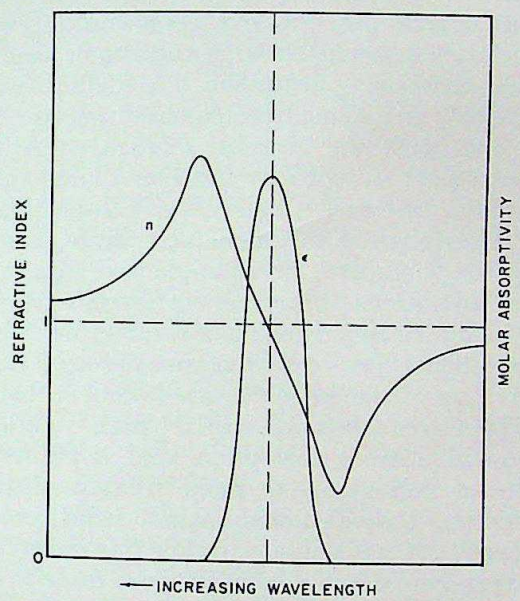

Figure 3. Theoretical absorption and dispersion curves.

Before our discussion of the analogous relationships between circular dichroism and rotatory dispersion a few additional important features of the absorption-dispersion curves will be considered. One very striking difference is that the absorption phenomenon is exhibited over a relatively small wavelength region but the dispersion manifests itself at wavelengths very far removed from the absorption band. This can be turned to advantage for chemical studies. For example, it is sometimes convenient to determine concentrations of solutions or the purity of compounds having absorption bands in the ultraviolet by measuring their refractive indexes in the visible region. Furthermore, it should be clear that since the dispersion and absorption curves are related, it might be possible to use refractive index measurements in the visible as aids in molecular structure determinations just as absorption spectra are often used. Thus an unsaturated compound with an absorption band in the near ultraviolet could be recognized not only by the *absorption* characteristics of this band but also by the increase in refractive index in the visible compared to a similar saturated compound lacking the absorption band. In the terminology used in this type of study it would be said that the unsaturation causes an "exaltation" of the refractive index. By using the Sellmeier relationship (*3*) between refractive index and wavelength, it might even be possible on occasion to estimate the location of the absorption bands. But now the manifestation of dispersion effects over large wavelength regions can become troublesome, because it is difficult to separate contributions from distant, strongly absorbing bands. For this reason it is more desirable (and much simpler) to measure the absorption bands directly with an ultraviolet spectrophotometer. Since these are now so commonly available, neither the qualitative nor quantitative applications of refractive index measurements are as important as they once were.

Circular Dichroism and Rotatory Dispersion

Until now in the discussion it has not been crucially important to specify whether or not we are considering measurements made with unpolarized or polarized light. We will now consider different effects which arise from using polarized light and will show that "circular dichroism" and "rotatory dispersion" are absorption and dispersion phenomena analogous to ordinary absorption and dispersion.

There are two types of polarization which will be discussed. These are plane and circular polarization. Plane polarized light has its electric vector vibrating in

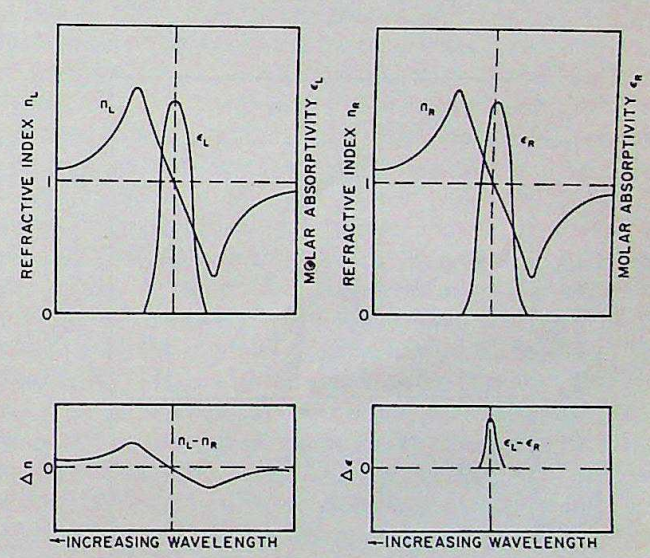

Figure 4. Top, theoretical absorption and dispersion curves measured with left and right handed circular light. Bottom, difference curves for a compound exhibiting anomalous rotatory dispersion and circular dichroism.

one plane, while the electric vector of circular light rotates as the light beam advances. The vector can rotate clockwise or counter-clockwise (as observed when facing the light source) and the light is said to be right- or left-handed circularly polarized respectively. (The appendix contains a brief description of the relationships among various types of polarized light and the methods used to produce polarization.)

The upper graphs of Figure 4 show the results of a typical dispersion and absorption measurement using left- and right-handed circular light. The results are clearly very similar. In fact unless the compound studied is optically active the two sets of data will be

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identical to the same measurements made on a gaseous or dissolved material with unpolarized light. But, if an optically active compound is studied, there will be very small but important differences between these curves. When a substance has a difference in its refractive index for right and left handed light, it is said to exhibit "circular birefringence." As discussed in the appendix, this leads to what is commonly described as "optical activity." By analogy with ordinary dispersion, a curve showing the wavelength dependence of circular birefringence is called a "rotatory dispersion curve." When a substance *absorbs* right- and left-handed light differently, it is said to exhibit "circular dichroism." This name is used because the original studies of circular dichroism were made in the visible and it was found that when viewed by transmitted right- and left-handed light a solution of such a substance would be colored differently. A curve showing the wavelength dependence is called a circular dichroism spectrum.

The difference curves for refractive index and absorptivity are shown in the two small graphs at the bottom of Figure 4. The lower graphs were deliberately made smaller to emphasize the fact that the differences *are* small. For example, the differences between two refractive index curves are usually in the sixth decimal place! The differences in the absorption curves will commonly be about one hundreth as large as the absorption curves themselves (though they can be as large as 10% in favorable cases). Figure 5 shows

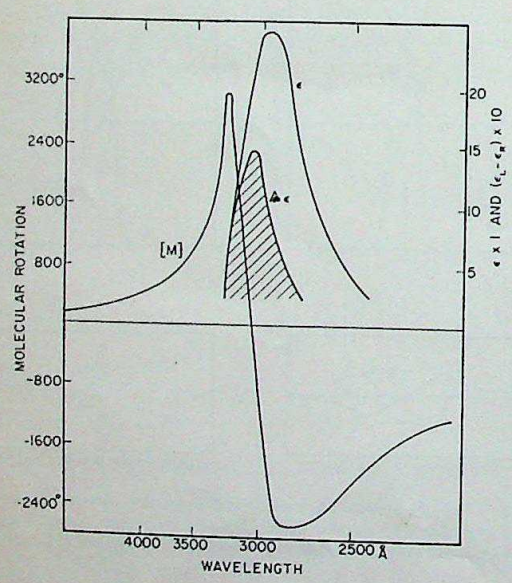

Figure 5. Absorption, rotatory dispersion and circular dichroism of camphor in hexane. Redrawn from Kuhn and Gorge (*4*).

some data for camphor as an illustration of the relationships among ordinary absorption, circular dichroism and rotatory dispersion (*4*). In this case measurements of rotatory dispersion were made through the entire band because the carbonyl group has a large rotation associated with this weak absorption. (The circular dichroism is not centered in the absorption band as it should be according to the simpler theories relating the two, but the reason for this is now understood (*5*).)

Many of the comments made earlier about ordinary dispersion curves also apply to rotatory dispersion. For example the optical activity of most compounds increases on going to shorter wavelengths because they have optically active absorption bands in the ultraviolet. For this reason, when a rotatory dispersion curve rises on going toward shorter wavelengths it is said to show "normal" dispersion. Near the optically active absorption band the dispersion curve falls with a decrease in wavelength so it is said to exhibit "anomalous" dispersion. In the middle of the absorption band the optical activity commonly goes to zero, and at shorter wavelengths changes sign. The name given to this combined phenomenon of anomalous rotatory dispersion and circular dichroism in an absorption band is the Cotton effect (*6*).

Thus far the analogies between ordinary absorption and dispersion, and circular dichroism and rotatory dispersion have been emphasized. But there is one difference of great practical and theoretical importance. With ordinary dispersion a large absorption band leads to a large anomalous dispersion. A small absorption band can only give a small anomalous dispersion. This is not true with the circular analogues. A strong absorption band may or may not give a large anomaly in the rotatory dispersion while a small absorption band may actually give rise to a moderately large anomalous dispersion. (Compare for example the almost nonexistent anomalous dispersion of cyclohexanone in Figure 1 with the large anomalous rotatory dispersion of Figure 5 which is caused by the same carbonyl chromophore.) One of the consequences of this is that if an optically active substance has a small rotation associated with a strong absorption band, it will be either difficult—or impossible—to make rotatory dispersion measurements through the absorption band because of insufficient light transmission. (For this reason during recent years considerable effort has been made to design more sensitive polarimeters. One has now been built with a sensitivity of approximately 10^{-5} degrees (*7*).)

Again, just as with ordinary dispersion and absorption data, theoretical relationships (the Kronig-Kramers equations) exist between circular dichroism and rotatory dispersion which permit calculating one curve from the other (*8*). This means that in principle no additional information can be obtained about a molecule by measuring both its rotatory dispersion and circular dichroism spectra.

However, there are practical considerations which sometimes make it advantageous to measure one or the other. These considerations parallel the ones discussed for ordinary dispersion and absorption. For example the rotatory dispersion of a molecule can be measured a long ways from the optically active absorption band causing it. Such measurements in the visible region can be used to determine concentrations, optical purity, rates of reaction, etc., but basically what is being studied is the circular dichroism of an absorption band at a shorter wavelength.

When it is not possible to make measurements of rotatory dispersion through absorption bands, it is still possible to estimate the wavelength of the circular dichroism band by fitting the data to a Drude equation. This is analogous to using the Sellmeier equation for locating absorption bands with ordinary dispersion

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data and it suffers from the same drawbacks, viz., that it is difficult to separate contributions from even rather distant bands. At the present time it is a simple matter to locate ordinary absorption bands with a spectrophotometer. Until recently, however, it was not possible to readily measure the circular dichroism spectrum, especially in the ultraviolet; but at least one commercial instrument is now available which will do this. This promises to be very useful since it will permit the independent examination of the circular dichroism bands of molecules with several optically active chromophores.

Conclusion

This now completes the brief discussion of the relationships among absorption, dispersion, circular dichroism, and rotatory dispersion. These relations and analogies are very simple, provided that only the phenomena themselves are considered and not their underlying causes. The author feels that the unified view this provides for these four superficially unrelated phenomena is very valuable. If, for example, the relationships between circular dichroism and rotatory dispersion were taught in all physical chemistry courses 50 years ago, would as much effort have been largely wasted by chemists on the interpretation of the optical activity of molecules at the sodium *D* line? The author believes that a clearer understanding of these relationships would have hastened the development of methods for measuring both circular dichroism and rotatory dispersion in the ultraviolet.

In order not to obscure the basic simplicity of the relationships already discussed a number of related topics will be considered in an appendix. The individual topics will be only briefly considered and references indicated for additional information.

Applications to chemical problems have only been touched on since they are covered in great detail elsewhere. Weissberger's "Physical Methods of Organic Chemistry" has one chapter devoted to refractometry (*9*) and the interpretation of refractive index and dispersion data. There are a very large number of excellent books devoted to absorption spectrophotometry (*10*, *11*). Applications of rotatory dispersion measurements are covered in some detail in a recent monograph (*8*), and similar applications can be made of circular dichroism spectra. This book also includes a very clearly written chapter by Moscowitz on the relationships between rotatory dispersion and circular dichroism. A partial summary of the early experimental and theoretical work on circular dichroism and rotatory dispersion was recently published by a pioneer in this field, W. Kuhn (*12*).

Appendix

Elliptical, Circular, and Plane Polarized Light. As judged by an observer stationed at some point along an advancing light beam the electric vector of *plane* polarized light oscillates in one plane in a sinusoidal manner. *Circularly* polarized light has a *rotating* electric vector of constant magnitude. Thus the projection of the tip of the electric vector of circular light onto a plane perpendicular to the direction of propagation will give a circle. A third, more general type of polarization, is elliptical polarization. In this case the projection of the vector tip will give an ellipse.

There are many relationships among these types of polarized light but only those of importance for this article will be mentioned. First, a plane polarized beam can be conceptually (and literally) resolved into right- and left-handed circular light components of equal magnitude. Second, if there is a phase shift between the two circular components this is equivalent to rotating the plane of polarization. And third, if there is a change of magnitude of one circular component relative to the other, elliptical light will result.

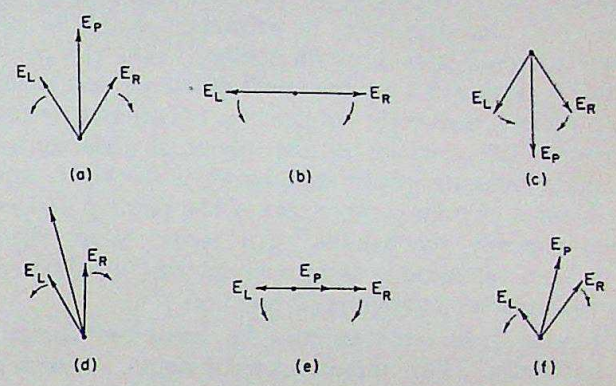

Figure 6. The circular components of light in various states of polarization; see text. The light beam is advancing toward the observer.

These three statements can be graphically demonstrated by reference to Figure 6. Figure 6*a*–*c* represent the resolution of plane polarized light with an electric vector E_p into circular components with rotating vectors E_r and E_l. The first three drawings indicate the appearance of the two circular and the one resultant linear component at a particular point in space at three different times. Notice in Figure 6*b* that the E_r and E_l vectors cancel one another at one point in the cycle. If there is a phase shift of one circular vector with respect to the other, this will lead to a rotation of the plane of polarization of E_p as shown in Figure 6*d*. If one circular component is reduced in magnitude relative to the other (as when a plane polarized beam passes through a solution exhibiting circular dichroism), the light will become elliptical as in Figure 6*e*, *f*. Notice that in this case there is no position comparable to Figure 6*b* in which cancellation occurs, so the resulting light cannot be plane polarized. Furthermore, since the magnitude of the *resultant* changes with time (compare Figure 6*e* and 6*f*), it cannot be circular light.

Production of Circular Light. Circular light can be produced by passing plane polarized light through an optical device known as a quarter wave plate. The quarter wave plate is made of a material having along two axes two different refractive indexes for plane polarized light. A light beam with a plane of polarization incident at ±45° to these axes will emerge from the plate with two orthogonal components traveling in the same direction, but with a quarter wave phase difference between them. The resultant of two such waves is a circularly polarized wave of either right- or left-handedness, depending on whether the orientation of incident light vector is plus or minus 45° to the axes. A typical quarter wave plate is a thin sheet of mica.

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For a very lucid introductory discussion of the properties of polarized light the reader is referred to "Optics" by F. W. Sears (*13*). (Notice in particular Figures 7–16, 17, and 23 of this reference.) A more complete treatment of these topics can be found in any advanced level optics text (*3*).

Measurement of Rotatory Dispersion and Circular Dichroism. Since optical activity is observed in any substance with a difference in refractive index for right and left handed circular light, it should be possible to measure this directly with a refractometer. For example, a Rayleigh interferometer could be used with a polarizer and quarter wave plate in each beam to measure the refractive index difference directly. However, the difference in refractive index is too small to make this a useful method. On the other hand, it turns out that the small difference can easily be measured indirectly by using a polarimeter which measures the rotation of the plane of polarization resulting from the phase shift between the right- and left-handed circular components of the plane polarized beam entering the sample. (In recent years there have been remarkable improvements in polarimetry. For examples see references (*7*) and (*14*).)

Circular dichroism can also be measured directly or indirectly. For direct measurements, polarizers and quarter wave plates (giving right- and left-handed circular light) could be inserted in the beams of a double beam spectrophotometer and the difference in absorbance measured with the same circularly dichroic sample in both beams. There are practical difficulties in such a direct measurement but recently a commercial instrument has been produced which does measure dichroism directly. For the principle of its operation see Legrand and Grosjean (*15*). In the discussion of Figure 6*e* it was pointed out that circular dichroism leads to the production of elliptical light. By using a quarter wave plate in an appropriate manner it is possible to make an "ellipsometer" which will measure the ellipticity of light (and therefore, indirectly the circular dichroism of a sample (*16*)).

Physical Origin of the Absorption-Dispersion Relationships. When the relationships between absorption and dispersion were first discovered, explanations were proposed by analogy with the behavior of a damped harmonic oscillator. If such an oscillator is forced into motion by a force varying sinusoidally with time, the power consumption and displacement of the oscillator reach a peak when the frequency of the driving force is equal to the natural resonant frequency of the oscillator. It was proposed that molecules contain atomic or electronic oscillators with natural frequencies of oscillation. When these oscillators are set into motion by a light wave, they consume the maximum power at their resonant frequencies. This then is the origin of an absorption band. The oscillating electrons would also radiate light (since accelerated charged particles radiate), and the interaction of this scattered light with the original light beam leads to the observed dispersion anomalies. A detailed discussion of this point is lengthy but involves no conceptual diffiulties. At a much later date these ideas were reformulated in wave mechanical terms.

A very clear discussion of this problem in both classical and wave mechanical terms can be found in "Quantum Chemistry" by W. Kauzmann (*17*) and in (*10*).

Other Absorption-Dispersion Phenomena. In addition to the two "paired phenomena" discussed in the text there are a number of others of some chemical importance such as absorption-dispersion of the infrared, radio frequencies (electron spin and nuclear magnetic resonance), X-rays, and the Faraday effect. These will now be very briefly considered.

The extension of the text's discussion of absorption-dispersion in the electronic spectral region to the infrared is very obvious. An understanding of infrared absorption-dispersion is useful in discussing the reasons for needing a number of prisms in infrared spectrophotometers to obtain adequate dispersion with reasonable prism transmission.

At still lower (radio) frequencies one can observe electron spin resonance (*18*) and nuclear magnetic resonance (*19*) spectra. Both resonance phenomena exhibit absorption and dispersion modes exactly analogous to the ones already discussed. Just as in the ultraviolet, visible, and infrared regions, radio frequency absorption spectra are more important than dispersion measurements. But there are situations where conditions are more favorable for the latter (*18*).

At very high frequencies, in the X-ray region, absorption-dispersion is also observed. An understanding of this is helpful in studying the technique used by Bijvoet in determining the absolute configuration of tartaric acid (*20*).

The induction of optical activity in a substance by a magnetic field is known as the Faraday effect. It also shows the expected relationships between its magnetic rotatory dispersion and magnetic circular dichroism (*21*). Recently it has been suggested that a study of the anomalous dispersion of the Faraday effect might provide a useful method of identifying singlet-triplet transitions (*22, 23*).

Another example of a paired phenomenon of chemical importance is the dielectric loss factor and the dispersion of the dielectric constant (*24*). Also of importance are the absorption and dispersion of sound (*25*). Sound dispersion measurements have recently been exploited for studying very fast chemical reactions (*26*).

Finally two systems which are useful in discussing the physical basis for the absorption-dispersion phenomena are the damped harmonic oscillator (*17*) and the resonant RLC electrical circuit. A general treatment of the formal mathematical relationships (such as the Kramers-Kronig equations) between all of these paired phenomena can be found in a paper of Macdonald and Brachman (*27*).

Literature Cited

(1) Allsopp, C. B., *Proc. Royal Soc. (London)*, A146, 300 (1934).
(2) Taylor, A. M., and Glover, A. M., *J. Opt. Soc. Am.*, **23**, 206 (1933).
(3) Ditchburn, R. W., "Light," Blackie and Son, London, 1952.
(4) Kuhn, W., and Gorge, H. K., *Z. Phys. Chem. (Leipzig)*, (B)12, 389 (1931).
(5) Moffitt, W., and Moscowitz, A., *J. Chem. Phys.*, **30**, 648 (1959).
(6) Cotton, A., *Ann. Chim. Phys.*, **8**, 360 (1896).
(7) Ridgeway, D., *Proc. Nat. Acad. Sci. U.S.*, **48**, 1482 (1962).
(8) Djerassi, C., "Optical Rotatory Dispersion," McGraw-Hill, New York, 1960.
(9) Bauer, N., Fajans, K., and Lewin, S. Z., in "Physical

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Methods of Organic Chemistry," 3rd ed., A. Weissberger, ed., Interscience Publishers, New York, 1960, Vol. 1, Part 2, chap. 18.
(10) Bauman, R. P., "Absorption Spectroscopy," John Wiley, New York, 1962.
(11) Gillam, A. E., and Stern, E. S., "An Introduction to Electronic Absorption Spectroscopy in Organic Chemistry," Edward Arnold, London, 1957.
(12) Kuhn, W., "Optical Rotatory Power," *Ann. Rev. Phys. Chem.*, 9, 417 (1958).
(13) Sears, F. W., "Optics," Addison-Wesley, Cambridge, Mass., 1949.
(14) Gillham, E. J., *J. Sci. Inst.*, 34, 435 (1957).
(15) Grosjean, M., and Legrand, M., *Comptes Rend. Acad. Sci.*, 251, 2150 (1960).
(16) Jaeger, F. M., "Spatial Arrangements of Atomic Systems and Optical Activity," McGraw-Hill, New York, 1930.
(17) Kauzmann, W., "Quantum Chemistry," Academic Press, New York, 1957.
(18) Fraenkel, G. K., in "Physical Methods of Organic Chemistry," A. Weissberger, ed., Interscience Publishers, New York, 1960, Vol. 1, Part 4, p. 2801.
(19) Gutowsky, H. S., "Physical Methods of Organic Chemistry," ed. A. Weissberger, Interscience Publishers, New York, 1960, Vol. 1, Part 4, p. 2663.
(20) Bijvoet, J. M., *Endeavour*, 14, 71 (1955).
(21) Lowry, T. M., "Optical Rotatory Power," Longmans, Green, London, 1935.
(22) Shashoua, V. E., *J. Am. Chem. Soc.*, 82, 5505 (1960).
(23) Smyth, C. P., "Dielectric Behavior and Structure," McGraw Hill, New York, 1955.
(24) Eberhardt, W. H., and Renner, H., *J. Molec. Spectrosc.*, 6, 483 (1961).
(25) Richardson, E. G., *Rev. Mod. Phys.*, 27, 15 (1955).
(26) Eigen, M., *Disc. Faraday Soc.*, 17, 194 (1954).
(27) Macdonald, J. R., and Brachman, M. K., *Rev. Mod. Phys.*, 28, 393 (1956).

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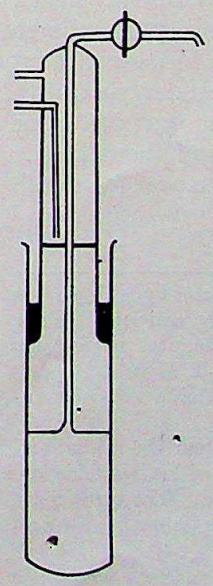
A Reaction Vessel for Kinetic Studies below Room Temperature

We are studying some reactions of cobalt complexes of the type

$$Co(NH_3)_5X^{2+} + OH^- \rightarrow Co(NH_3)_5OH^{2+} + X^-$$

which are too rapid to be examined by conventional methods above 10°C under the conditions of immediate interest. As room temperature here approaches 30°C it is difficult to remove aliquots without raising the temperature of the sample. This would introduce large errors since these reactions also have high energies of activation.

We have overcome this problem by use of a piston reactor similar in principle to that first described by Farhat-Aziz and Moelwyn-Hughes.[1] The modified vessel is shown in the drawing. The outer barrel consists of precision bore tubing of 34.5 mm diameter and is about 10 in. in length. About 3 in. of a ground glass piston attached as shown serve as a seal for the plunger. Samples are obtained by opening the stopcock and depressing the plunger. The plunger is divided into two compartments by a glass-partition with the lower compartment evacuated and sealed off to reduce heat transport from one section to the other. The thermostat, in which the reactor is placed, is a water bath which is cooled by circulating liquid at a temperature of 10–20°C below the desired bath temperature. Temperature control is obtained by electrical heating, a mercury thermoregulator, and electronic relay in the usual manner. The cold liquid is also circulated through the upper chamber of the plunger using the inlet and outlet tubes shown. This ensures that the inner tube through which the reacting solution has to pass for sampling, is at a much lower temperature than the thermostat temperature. By wasting a little of the solution prior to sampling the portion of the tube beyond the stopcock is also cooled. The aliquots are therefore cooled during sampling and quenching is completed by collecting the sample in a cold tube containing a small volume of 73% perchloric acid. The small amount of mercury which acts as seal for the piston also prevents any leakage of condensed water from the top of the piston into the vessel. There is no contact between the mercury and the liquid contained below the piston.



Reaction vessel

Acknowledgment is made to Mr. N. Baney for constructing the apparatus.

[1] Farhat-Aziz, and Moelwxn-Hughes, E A., *J. Chem. Soc.*, 1959, 2638.

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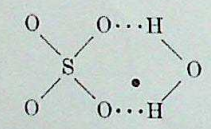
Textbook Errors, 47

On Hydrogen Bonds

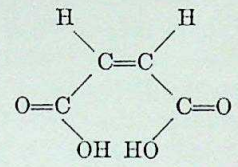
While the precise geometry of hydrogen bonds may appear, at first sight, to be a rather trivial property on which to center attention, it was just such attention to detail which led, for example, to the formulation of protein structures by Pauling and Corey and to the Watson-Crick hypothesis for the structure for DNA. It thus seems important to call attention to examples of errors which are at present being propagated in textbooks.[1] A student can hardly be expected to develop a proper feeling for the geometry of hydrogen bonding if he is presented with impossible structures.

One of these purports to give a partial arrangement of the water molecules in $CuSO_4 \cdot 5H_2O$. The determination of the structure of this compound, by X-ray diffraction[2] found an elongated octahedral coordination for the copper atoms: four H_2O arranged in a square about each Cu^{+2}, with two more distant oxygen atoms of different sulfate ions completing the octahedron. The fifth water molecule bridges two sulfate groups of different $Cu(H_2O)_4^{++}$ complexes. Therefore, to formulate—as has frequently been done—the following complex,

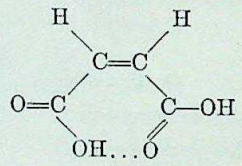


where one water molecule forms two hydrogen bonds to the same sulfate ion, is not only contrary to the crystallographic results but also does violence to the geometrical requirement of a linear, or nearly linear O—H···O system. It is obviously not possible to construct such a complex without introducing an unacceptably large deviation of the angle O—H···O from 180° or without the requirement that the angle H—O—H deviate from a nearly tetrahedral value and to preserve at the same time the characteristic O···O distances of about 2.8 Å.

Another related error involves maleic acid for which the crystal structure known from X-ray diffraction.[3] This structure has been misinterpreted in one textbook as follows, and the error has now found its way into at least one other textbook.

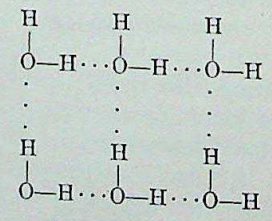


The above formulation in which the two hydroxyl groups point at each other brings the two hydrogen atoms impossibly close to each other and thus is obviously incorrect. The original X-ray study implies the correct formulation:

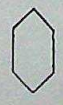


This may be arrived at by identification of the carbon-oxygen bonds of 1.20 and 1.21 A as the two C=O bonds and those of 1.27_5 and 1.27_5 Å as the two C—OH bonds (the hydrogen atoms were not located directly). One hydroxyl group is involved in intramolecular hydrogen bonding, the other in intermolecular, a result in complete agreement with expectation.

Other examples of geometrically unacceptable hydrogen bonds may easily be found in textbooks, but these are quite often the result of exigencies of typography rather than an incomplete understanding of the geometry of the interactions. For example:



does not represent the correct geometrical situation in ice, where each oxygen atom is tetrahedrally surrounded by four others. This and other examples fall into the same class as do many conventional figures used in texts and journals, such as



for the regular hexagonal benzene ring. In that instance, it is probably not necessary to emphasize the difference between the printed page and reality. A

Suggestions of material suitable for this column and guest columns suitable for publication directly are eagerly solicited. They should be sent with as many details as possible, and particularly with references to modern textbooks to Karol J. Mysels, Department of Chemistry, University of Southern California, Los Angeles 7, California.

[1] Since the purpose of this column is to prevent the spread and continuation of errors and not the evaluation of individual texts, the source of errors discussed will not be cited. The error must occur in at least two independent standard books to be presented.

[2] Beevers, C. A., and Lipson, H., *Proc. Roy. Soc.*, A146, 570 (1934).

[3] Shahat, M., *Acta Cryst.*, 5, 763 (1952).

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word of caution in the case of hydrogen bonds, on the other hand, appears to be appropriate.

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The question of what the student *should* be taught is readily answered. The concept of a hydrogen bond was first introduced[4] in order to explain some of the anomalous properties of water, acetic acid, ammonium hydroxide, etc., in terms of an interaction between the hydrogen atom of an >N—H, \O—H, or F—H group with an electronegative atom such as fluorine, oxygen, or nitrogen. The properties of such "hydrogen bonds" have since been extensively investigated by numerous methods. This interaction is now considered to be essentially electrostatic in nature, and the conventional symbols N—H···O, O—H···O, and the like, imply two conditions which have, in fact, been amply verified by direct experiment. Direct experiment has shown that the hydrogen atom lies on, or close to, a line joining the two heavier, electronegative atoms, and that it is much closer to one of these atoms than the other, corresponding to a covalent bond on the one hand and the electrostatic interaction on the other.[5] It is probably desirable to emphasize these two conditions when first discussing hydrogen bonded structures. Comprehensive reviews are available[6] in which the various properties of hydrogen bonds are discussed.

[4] LATIMER, W. M., AND RODEBUSH, W. H., *J. Am. Chem. Soc.*, 42, 1419 (1920).

[5] So-called "symmetrical" hydrogen bonds, such as F···H···F in KHF_2, and "bifurcated" hydrogen bonds, such as N—H:(O)(O) in nitramide, represent exceptions to the usual behavior, and other examples of these have been only very rarely encountered.

[6] Pauling, L., "The Nature of the Chemical Bond," 3rd ed., Cornell University Press, 1960, chap. 12, together with the reviews cited on p. 449.

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Cyclobutane Chemistry

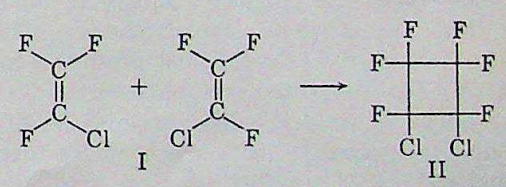
2. *Reactions and Mechanisms*

The following discussion on synthetic approaches to cyclobutanes is intended to acquaint the reader with the more recent works in this field. For those who are interested in the historical developments of cyclobutane preparations, some lead articles and books are included in reference (*1*) of the previous paper.[1]

Although borderline cases exist, we have attempted to categorize the reactions into free radical (thermal and photochemical) and polar-type cyclizations. Where mechanisms have not been included in the original paper, an effort has been made to propose a possible path of reaction. Moreover, we have limited ourselves to those syntheses which offer most promise with regard to facility and scope of preparation.

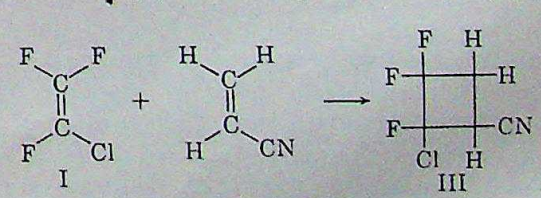
Free Radical Cyclizations (Thermal)

Homocyclization of Perhaloethylenes and Cyclization of Perhaloethylenes with Olefins and Acetylenes (*53*). Chlorotrifluoroethylene (I) dimerizes to give a product which is approximately 50-50 *cis* and *trans* 1,2-dichlorohexafluorocyclobutane (II). This thermal cycloaddition is carried out by heating at 180–200°C in an air free, stainless steel autoclave in the presence of a free radical inhibitor to prevent linear polymerization.



Homocyclization occurs easily with compounds of the type $CF_2{=}CX_2$, only if X is halogen. The thermal cyclization of chlorotrifluoroethylene (I), tetrafluoroethylene and 1,1-dichloro-2,2-difluoro-ethylene give 80–90% yields of the cyclobutanes.

Cycloaddition of (I) with acrylonitrile forms 3-cyano-2-chloro-1,1,2-trifluorocyclobutane (III) (*54*).



[1] For the first article of this pair see THIS JOURNAL, 40, 504 (1963). Literature citations are numbered consecutively for the two papers.

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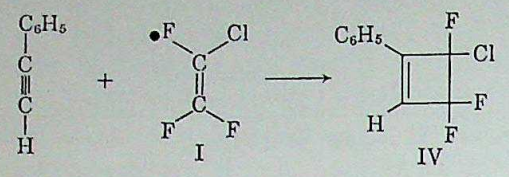
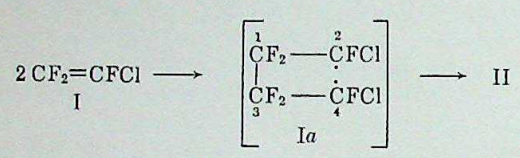
When chlorotrifluoroethylene (I) is treated with phenylacetylene in a sealed tube at 120° for 24 hr, 1,1,2-trifluoro-2-chloro-3-phenylcyclobutene (IV) is formed in yields up to 75% (*55, 56*).



With this group of reactions in mind, one can theorize on the following question: What are the influential factors involved in the direction of addition of unsymmetrical haloethylenes to themselves and to other symmetrical olefins? J. D. Park explains orientation of the reactants on the basis of the most stabilized diradical in the product-determining transition state. For example, in the homocyclization of (I), (I*a*) would be the diradical of lowest energy since the stability of free radicals is governed by the nature of the halogen (i.e., I>Br>Cl>F) (*57*).

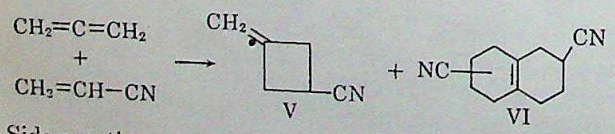


The orientation of cycloaddition of these types of olefins can be predicted by assuming a diradical similar to (I*a*) which is most stabilized with respect to such olefin substituents as halogen, nitrile, aromatic, and other electronegative groups.

A concerted rather than a stepwise diradical intermediate has also been proposed in thermal cycloadditions (*58, 59*). This would entail a simultaneous formation of bonds between C-1,3 and C-2,4, eliminating the possibility of free rotation about bonds C-1,2 and C-3,4. The concerted process thereby predicts a stereospecific addition. In view of the fact that a 50:50 *cis-trans* isomer distribution of products was isolated, the stepwise diradical mechanism is favored in this case.

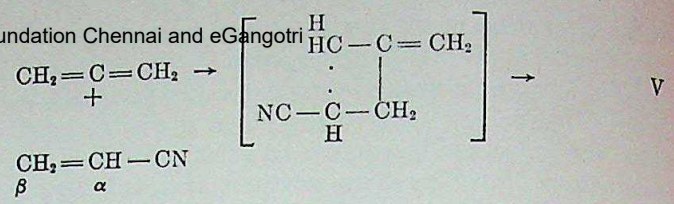
Cycloaddition of Allenes to Olefins (*60*). Thermal cycloaddition of allenes and olefins substituted with nitrile, carboxyl, carboalkoxy, aldehyde, and aryl groups form 3-methylene cyclobutanes. This extends the realm of cycloaddition products to nonfluorinated 1,3 disubstituted cyclobutanes.

When allene is treated with acrylonitrile at 200°, 3-methylene cyclobutane carbonitrile (V) is formed in 60% yield.

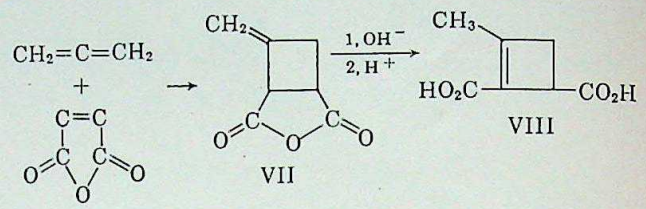


Side reactions occur due to the dimerization of allene to 1,2 dimethylenecyclobutane with subsequent addition of acrylonitrile to form the octahydronaphthalene (VI). These side reactions are noticeably diminished when an excess of the olefin portion is employed.

A possible mechanism involves reaction of the central allene carbon with the β carbon atom of acrylonitrile to render the most stabilized diradical. Cyclization follows electron pairing of the diradical (*59*).

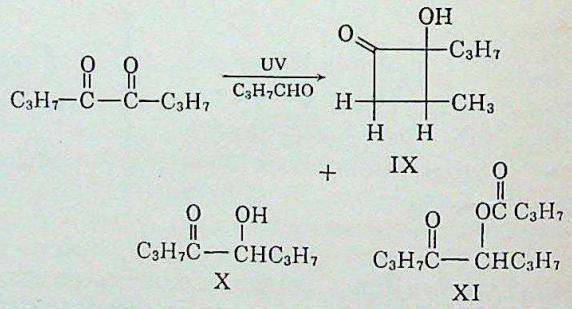


Maleic anhydride and allene form the adduct, 3-methylenecyclobutane 1,2-dicarboxylic anhydride (VII). Treatment with alkali and then acid converts the anhydride into 3-methyl-2-cyclobutene-1,2-dicarboxylic acid (VIII) in 84% yield. This latter intermediate is used to prepare a variety of functionally substituted cyclobutenes containing amide, amine, ester, hydroxyl, and nitrile groups (*61*).



Free Radical Cyclizations (Photochemical)

Excellent yields of 2-hydroxycyclobutanones are obtained through photolysis of certain 1,2-diketones (*62*). For instance, when 4,5-octanedione was irradiated in butanal at 30–35° for 23 hr, a 92% yield of 2-hydroxy-3-methyl-2-propylcyclobutanone (IX) was formed. Small amounts of side products, 5-hydroxy-4-octanone (X) 8.7% and 5-oxo-4-octanol butyrate (XI) 7.7% were isolated. When butanal itself



is irradiated, 58% of (X) forms. This series of experiments indicates that there is a high selectivity for cyclobutane formation (i.e., intramolecular reaction) even in a solvent which is competitively reactive toward free radical attack.

However, a preference for reduction and carbonyl addition was reported in the photolysis of 3,4-hexanedione in propanal. In this case intramolecular reaction or cyclobutane formation involves a more unstable primary free radical rather than the more stabilized secondary free radical of the previous 4,5-octanedione cyclization. Hence, only 23% of 2-ethyl-2-hydroxycyclobutanone was formed along with a majority of propanal free radical products, 4-hydroxy-3-hexanone (23%) and 4-oxo-3-hexanol propionate (54%). When 3,4-hexanedione was exposed to sunlight in the more inert solvent, cyclohexane, a 60% yield of the cyclobutanone formed.

These reactions support the proposed mechanism by W. H. Urry for the selective formation of 2-hydroxycyclobutanones. The diradical forms a six-membered cyclic transition state for facile hydrogen atom transfer.

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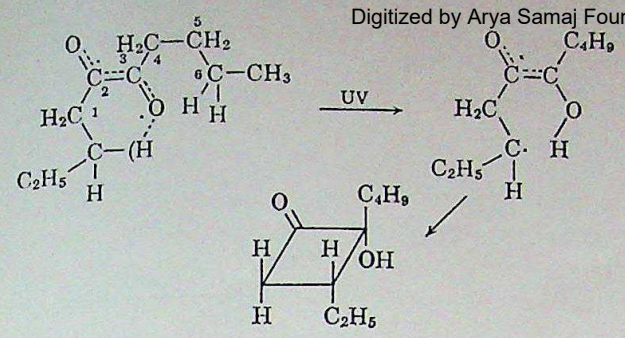
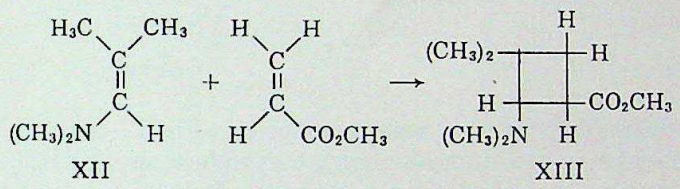


A *trans* structure is suggested in the triplet or single π^* state with double bond character between atoms 2 and 3 and thus coplanarity with the oxygen atoms and carbon atoms 1, 2, 3, and 4. If this were not so then the alternate path, formation of 1-alkanoyl-cyclobutanols, could occur by attainment of a favorable arrangement of carbon atoms 5, 6 and hydrogen 6 with respect to the carbonyl 3 oxygen. No 1-alkanoyl cyclobutanol is isolated in this highly specific reaction.

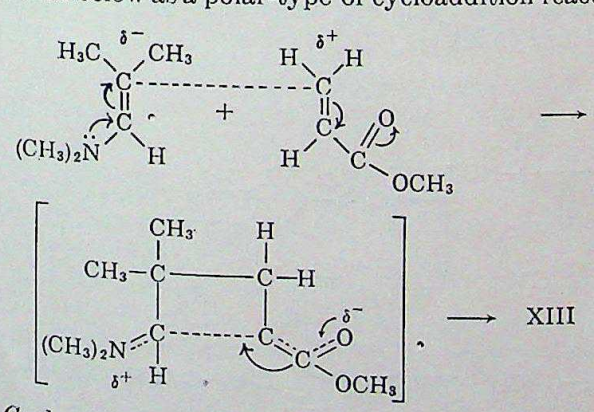
Polar-Type Cyclizations

Cycloaddition of Enamines with Electrophilic Olefins. Cyclobutanes are formed by the treatment of enamines, which lack β-hydrogen atoms, with electrophilic olefins, such as methyl acrylate and dimethyl maleate (*63, 64*).

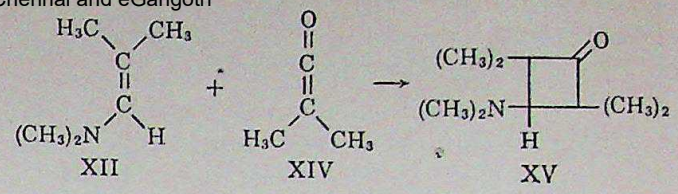


A 75% yield of methyl 2-dimethylamino-3,3-dimethyl cyclobutane-carboxylate (XIII) was reported when methyl acrylate and *N,N*-dimethylisobutenylamine (XII) were heated for two hours at 170°. Acrylonitrile, α,β-unsaturated sulfones, and nitro compounds also form cyclobutanes with isobutenylamines. K. C. Brannock has observed that cyclobutanes can be formed with enamines having one β-hydrogen if conditions are mild enough to avoid ring cleavage (*65*).

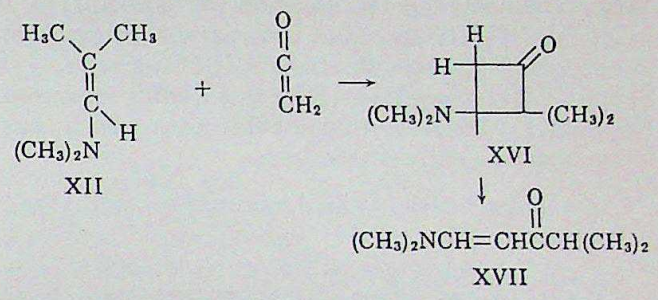
The orientation observed in formation of (XIII) is outlined below as a polar-type of cycloaddition reaction.



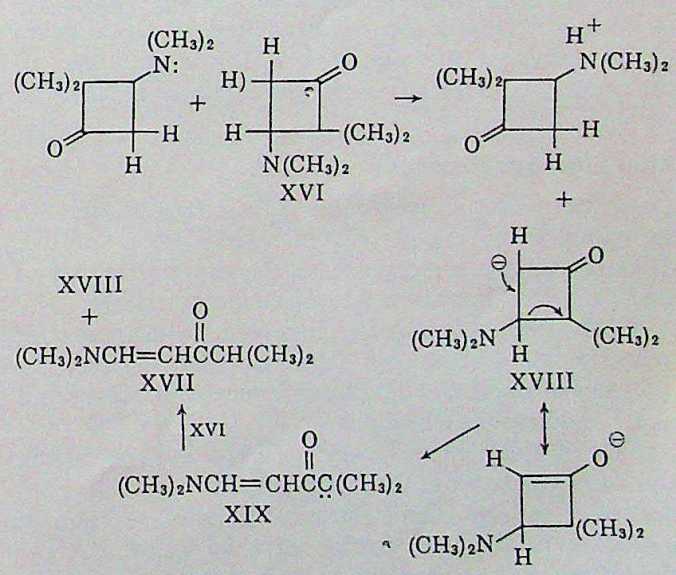
Cycloaddition of Ketenes to Enamines. Hasek and Martin have reported that the reaction of ketene or dialkylketenes with enamines give 3-dialkylamino-cyclobutanones (*66, 67*). Dimethylketene (XIV) and *N,N*-dimethylisobutenylamine (XII) react at room temperature in isopropyl acetate to give a 64% yield of 3-dimethylamino 2,2,4,4-tetramethylcyclobutanone (XV).



When ketene is treated with (XII) in hexane at 0°, 3-dimethylamino-2,2-dimethylcyclobutanone is formed. Upon warming, (XVI) undergoes a ring-opening to give a 93% yield of 1-dimethylamino-4-methyl 1 pentene-3-one (XVII).



Cyclobutanones, such as (XVI), having one or more α-hydrogens are subject to an irreversible ring cleavage, whereas cyclobutanones having no α-hydrogens, such as (XV), are quite stable. Ring cleavage is probably initially induced by the basic amine group which can readily abstract an acidic α-hydrogen. The cyclobutyl carbanion (XVIII) (partially stabilized by the ketone) can then reform into a conjugated enaminoketone with accompanying ring cleavage. The carbanion (XIX) formed from the rupture of the carbon-carbon bond can abstract a proton from another molecule of (XVI) and the chain of events is repeated again.



Opitz has treated *N*-morpholino-isobutene with propionyl chloride in the presence of triethylamine to form 2,2,4-trimethyl-3-morpholino-cyclobutanone. Presumably this reaction proceeds via the *in situ* formation of methyl ketene due to dehydrohalogenation of propionyl chloride by triethylamine. This is followed by cycloaddition of the ketene with the enamine (*68*).

Potassium Catalyzed Dimerization of β-Alkylstyrenes (*69*). When β-methylstyrene (65% *trans*, 35% *cis*) is added to a potassium metal dispersion in methyl

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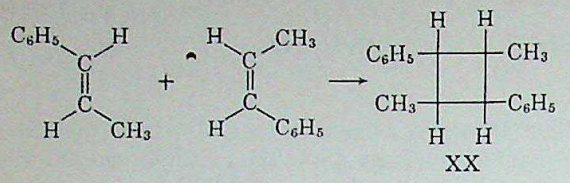
cyclohexane at 100°, the products are 50% of recovered β-methylstyrenes and 45% of stereoisomers of 1,3-dimethyl-2,4-diphenylcyclobutane (XX).



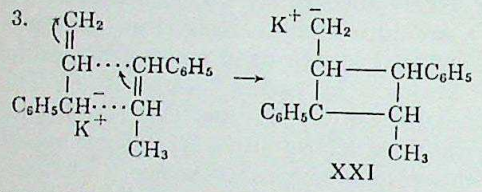
XX

The cyclobutane structure is supported by the following evidence:

(1) There was no olefin unsaturation in (XX).
(2) The NMR spectrum showed the presence of CH_3CH and the absence of CH_3CH_2-groups.
(3) On hydrogenolysis (XX) was wholly converted into 1,3-diphenyl-2-methylpentane which was independently synthesized.

The mechanistic path of the dimerization is visualized by Pines as follows:

1. $C_6H_5CH{=}CH\,CH_3 + K \rightarrow R^-K^+$
2. $C_6H_5CH{=}CH\,CH_3 + R^-K^+ \rightarrow C_6H_5CH{=}CH_2{}^-K^+ \leftrightarrow C_6H_5\bar{C}H\,CH{=}CH_2\ (K^+)$



XXI

4. $XXI + C_6H_5CH{=}CHCH_3 \rightarrow XX + C_6H_5CH{=}CHCH_2{}^-K^+$

In step three, stabilization of the primary carbanion is inferred as a result of the strain energy in the cyclobutane. This might be attributed to the overlap of π orbitals of the ring carbon atoms with that of the carbanion, a phenomenon which has been discussed earlier in this review.

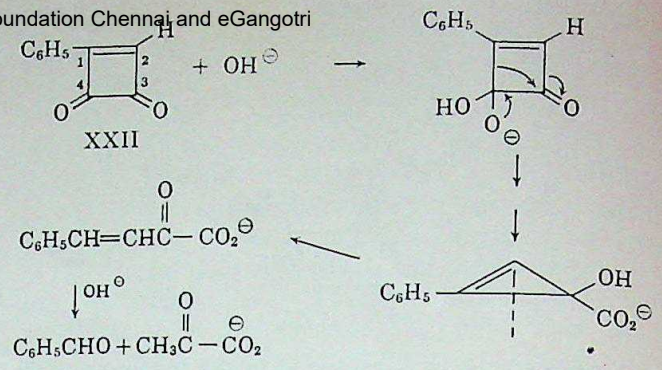
Ring Cleavage Reactions

A discussion of cyclobutane chemistry would not be complete if ring cleavage reactions were omitted. It is of extreme importance to the experimentalist to be aware that cleavage reactions can occur readily.

When cyclobutanes are involved in a series of reactions it is of utmost importance to confirm the presence of the intact ring by reference derivatives and NMR studies for each step.

Ease of cleavage will vary with the inherent strain of the cyclobutane, the substituents on the ring, nature of reagents, and the conditions of reaction as indicated in the first section of this review. A cyclobutane may cleave and then reform reversibly, form noncyclic compounds, or cleave and then reform into a different cyclobutane, a cyclopropane, or an enlarged ring. Some recent examples of these types of ring-opening reactions are presented.

An Alkaline Catalyzed Ring Opening of Phenylcyclobutenedione. When phenylcyclobutenedione (XXII) is boiled with a dilute solution of sodium hydroxide in methanol, benzaldehyde and benzylidenepyruvate are formed. An outline of this ring opening mechanism, as proposed by J. D. Roberts, is described below (*70*).

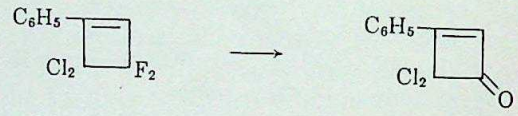


XXII

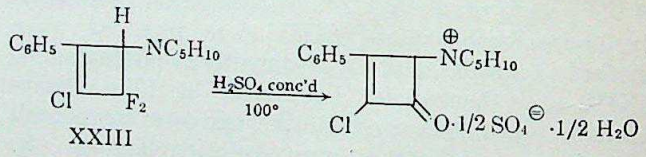
The base is believed to induce a type of benzilic acid rearrangement to give the cyclopropene intermediate (not isolated). The cyclopropene undergoes ring cleavage to give benzylidenepyruvic acid which is hydrolyzed to benzaldehyde and pyruvic acid in a reverse aldol condensation reaction.

Another possible path to the products is simultaneous ring cleavage of the $C_1 - C_4$ bond with hydroxide ion attack of the carbonyl carbon of phenylcyclobutadiene.

Ring-Opening Reaction of 1,1-Difluoro-2-Chloro-4-Piperidino-3-Phenyl-2-Cyclobutene. Fluorine-substituted phenylcyclobutenes can be converted into the corresponding ketones by treatment with concentrated sulfuric acid at 100°C (*71*).

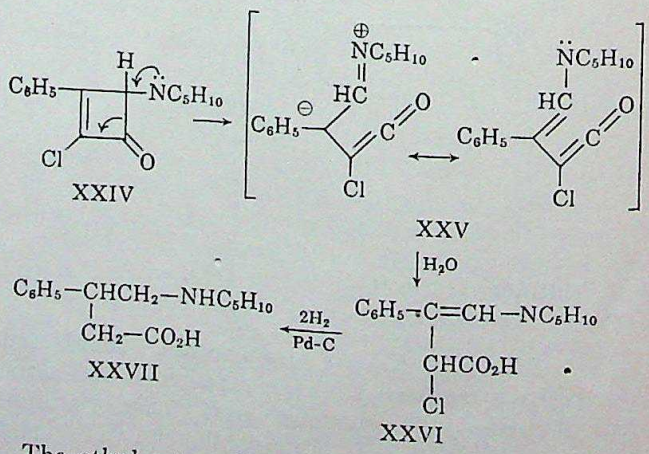


When this reaction was attempted with 1,1-difluoro-2-chloro-4-piperidino-3-phenyl-2-cyclobutene (XXIII), the ketone was isolated as a hydrate salt (*72*).



XXIII

This salt is partially hydrolyzed to the free base (XXIV) in anhydrous organic solvents and undergoes a thermal ring-opening reaction to form a vinyl ketene intermediate (XXV). This ketene intermediate can be trapped by adding water to form a β, γ-unsaturated acid (XXVI).



XXIV XXV XXVI XXVII

The ethyl ester of the corresponding hydrogenated free γ-amino acid (XXVII) was identical with an authentic sample of ethyl-3-phenyl-4-piperidinobutyrate.

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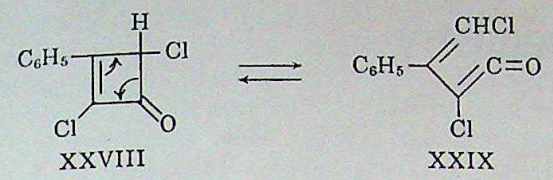
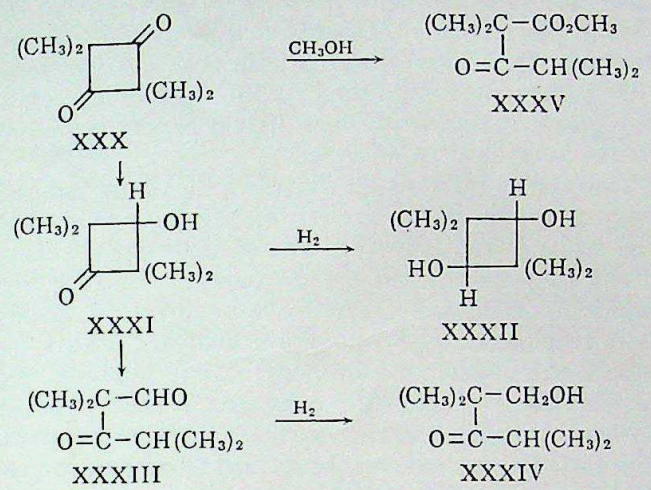
This ring opening is similar to the reversible formation of (1 - phenyl - 2 - chloroethenyl) - chloroketene (XXIX) from 2,4-dichloro-3-phenylcyclobutenone (XXVIII) in chloroform at 100°C (*72, 73*).

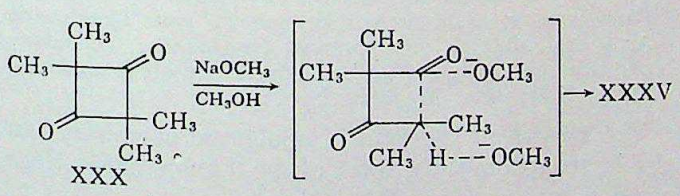


Catalytic Hydrogenation and Ring Cleavage by Alcohols. The catalytic hydrogenation of dimethylketene dimer was investigated and found to give cleavage products under certain conditions (*74*).



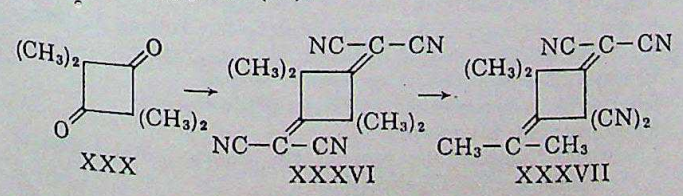
When (XXX) was hydrogenated in methanol with a ruthenium catalyst, a mixture of *cis* and *trans* (XXXI) was formed.

Hydrogenation of the dimethylketene dimer (XXX) in methanol over Raney nickel gave 1-hydroxy-2,2,4-trimethyl-3-pentanone (XXXIV) and methyl-2,2,4-trimethyl-3-oxovalerate (XXXV). The latter was formed slowly by methanolic cleavage of (XXX). Formation of (XXXV) was accelerated when catalyzed by alkaline reagents. One may propose an S_N2 mechanism to partially explain the increased rate of reaction when a stronger nucleophile is introduced.

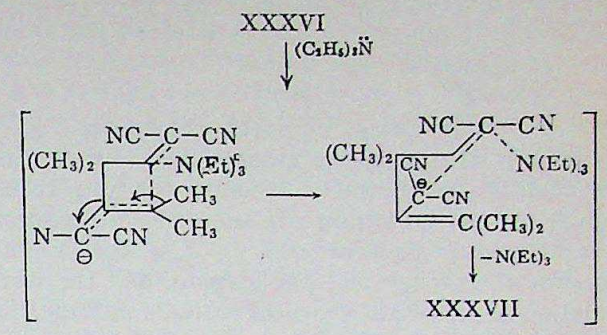


It would be of interest to study this reaction without hydrogenation to observe any influence of base alone on this cleavage.

A Nucleophilic-Catalyzed Ring Opening-Ring Closure Sequence. When the dione (XXX) was treated with malononitrile in pyridine solution, *bis*-(dicyanomethylene)- 2,2,4,4-tetramethylcyclobutane (XXXVI) was formed in 97% yield (*75*).



During treatment of (XXXVI) with triethylamine, a rearrangement occurred to give the isomeric 2,2-dicyano-3-isopropylidene-4,4-dimethyldicyanomethylenecyclobutane (XXXVII). A ring cleavage-ring closure sequence catalyzed by a nucleophile is proposed. An attempt to elucidate this mechanism is presented.



A nucleophilic attack by triethylamine cleaves the ring. The carbanion undergoes a resonance shift to form the isopropylidene substitutent and the dicyanomethane carbanion attacks the β carbon atom of the dicyanoethylene group thereby closing the ring.

Literature Cited

(53) Park, J. D., Holler, H. V., and Lacher, J. R., *J. Org. Chem.*, **25**, 990, (1960); Tarrant, P., Johnson, R. W., Jr., and Brey, W. S., Jr., *J. Org. Chem.*, **27**, 602, (1962).

(54) Barney, A. L., and Cairnes, T. L., *J. Am. Chem. Soc.*, **72**, 3193 (1950); Lorenzi-Thesis, F. J., University of Colorado, 1954.

(55) Smutny, E. J., and Roberts, J. D., *J. Am. Chem. Soc.*, **77**, 3420 (1955).

(56) Coffman, D. D., Barrick, P. L., Cramer, R. D., and Raasch, M. S., *J. Am. Chem. Soc.*, **71**, 490, (1949).

(57) Haszeldine, R. N., *J. Chem. Soc.*, **1953**, 1764.

(58) Coyner, E. C., and Hillman, W. S., *J. Am. Chem. Soc.*, **71**, 324 (1949).

(59) Roberts, J. D., "Organic Reactions," Vol. XII, John Wiley and Sons, Inc., New York, 1962, chap. 1.

(60) Cripps, H. N., Williams, J. K., and Sharkey, W. H., *J. Am. Chem. Soc.*, **80**, 751 (1958); **81**, 2723 (1959).

(61) Cripps, H. N., Williams, J. K., Tullio, V., and Sharkey, W. H., *J. Am. Chem. Soc.*, **81**, 4904 (1959).

(62) Urry, W. H., *J. Am. Chem. Soc.*, **84**, 118 (1962).

(63) Brannock, K. C., Bell, A., Burpitt, R. D., and Kelly, C. A., *J. Org. Chem.*, **26**, 625 (1961).

(64) Cook, A. G., Doctoral Dissertation, University of Illinois, 1959.

(65) Brannock, K. C., Enamine Symposium, ACS Meeting, Sept., 1961, Chicago, Ill.

(66) Hasek, R. H., and Martin, J. C., *J. Org. Chem.*, **26**, 4775 (1961).

(67) Berchtold, G. A., Harvey, G. R., and Wilson, G. E., Jr., *J. Org. Chem.*, **26**, 4776 (1961).

(68) Opitz, G., *Angew. Chem.*, **73**, 654 (1961).

(69) Pines, H., and Shabtai, J., *J. Am. Chem. Soc.*, **83**, 2781 (1961).

(70) Skattebol, L., and Roberts, J. D., *J. Am. Chem. Soc.*, **80**, 4085 (1958).

(71) Roberts, J. D., Kline, G. B., and Simmons, H. E., Jr., *J. Am. Chem. Soc.*, **75**, 4765 (1953).

(72) Jenny, E. F., and Druey, J., *J. Am. Chem. Soc.*, **82**, 3111 (1960).

(73) Jenny, E. F., and Roberts, J. D., *J. Am. Chem. Soc.*, **78**, 2005 (1956).

(74) Hasek, R. H., Elam, E. U., Marten, J. C., and Nations, R. G., *J. Org. Chem.*, **26**, 700 (1961).

(75) LaLancette, E. A., and Benson, R. E., *J. Am. Chem. Soc.*, **83**, 4867 (1961).

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The Current Prominence of Analytical Chemistry

Analytical chemists in the past have been viewed as a minority group doing very routine work of little significance. Actually, analysts today comprise the second largest portion of the registration of the American Chemical Society. Also, the number of analytical meetings and publications, and the wide circulation of analytical chemical journals indicate the current prominence of this aspect of chemical science.

Chemical and Engineering News (December 11, 1961, p. 123) printed a table showing the distribution of specialties within the ACS membership in 1960.

	Population
Organic chemistry	44.2%
Analytical chemistry	16.2
Physical chemistry	13.4
Biochemistry	9.8
Inorganic chemistry	7.3
Agricultural and food chemistry	5.9
Other	3.2

One quickly notes that analysts are the second largest group in the Society, outnumbering physical and inorganic chemists, and that there is one analyst for about every three organic chemists.

The upsurge in analysis began during or just after World War II with the expansion of the analytical "tool kit." The numerous instrumental devices which have been developed have greatly broadened the scope of analytical potential. In addition, the classical analytical approaches (volumetric, gravimetric, and combustion analysis) have not been lying idle or decaying; these also have been greatly expanded and streamlined.

One can follow the expansion of the analytical field by examining the history and content of the analytical chemical journals. *Analytical Chemistry* was first issued in 1929, a rather recent date. In the 33 years of its existence, it has grown to be second in circulation among ACS publications. The circulation of *Analytical Chemistry* (October, 1962) was larger than the combined circulation of the three next largest.

October, 1962, circulations are:

Industrial and Engineering Chemistry	
Analytical Chemistry	29,613
Journal American Chemical Society	28,999
Journal Organic Chemistry	15,981
Journal Physical Chemistry	7,253
	5,485

The 1929 volume of *Analytical Chemistry* contained approximately 100 papers in 240 pages. The 1961 volume contained 550 papers and 2000 pages. In addition to the growth of this one journal, one can see the establishing of several new publications in the field of analysis: *Talanta, Microchemical Journal* (soon to have a new name), *Analytica Chemica Acta, Journal of Chromatography, Informacion de quimica analytica*, and *Zhurnal Analitiskoi Khimii*. Of course, the older analytical journals also have expanded; these are *The Analyst, Zeitschrift für Analytische Chemie, Microchemie* (*Microchemica Acta*) and *Chemist-Analyst*. It is interesting to note that in 1962 some 2100 papers were published in the field of gas chromatography alone, with over 10,000 papers estimated for the total field of analysis.

The above publication statistics serve to indicate the magnitude of the growth of the analytical field. The scope of the growth is indicated by the diversity of the subjects covered by the papers. In 1929, the papers in *Analytical Chemistry* were involved mainly with gravimetric and volumetric analysis, with some papers on emission spectroscopy, X-ray analysis, and determination of physical constants. There was no Review issue for 1929 since the field was so small. The 1962 Review issue of Analytical Chemistry covers 38 different areas of analytical specialty:

Biochemical Analysis; Chromatography; Electrochromatography; Gas Chromatography; Ion Exchange Chromatography; Distillation Analysis; Electroanalysis and Coulometric Analysis; Extraction; Fluorometric Analysis; Gas Analysis; Instrumentation; Ion Exchange; Inorganic Microchemistry; Organic Microchemistry; Chemical Microscopy; Electron Microscopy; Nucleonics; Polarographic Theory, Instrumentation, and Methodology; Organic Polarography; Emission Spectrometry; Absorption Flame Photometry; Emission Flame Photometry; Infrared Spectrometry; Light Absorption Spectrometry; Mass Spectrometry; Magnetic Resonance Spectrometry; Raman Spectrometry; Ultraviolet Spectrometry; X-Ray Absorption and Emission; Statistical Methods in Chemistry; Differential Thermal Analysis; Titrations in Nonaqueous Solvents; Amperometric Titrations; Potentiometric Titrations; Volumetric and Gravimetric Analytical Methods for Inorganic Compounds; Volumetric and Gravimetric Analytical Methods for Organic Compounds; X-Ray Diffraction; Magnetic Susceptibility.

The growth of the field of analytical chemistry can also be seen from the growth of the number of meetings specifically concerned with analysis.

Pittsburgh Analytical Conference
Annual Analytical Symposium
Gordon Research Conference on Analytical Chemistry
Gordon Research Conference on Instrumentation
Gordon Research Conference on Infrared Spectroscopy
Louisiana State Analytical Symposium
Anachem Meeting
Analytical Division Symposia at ACS meetings
Regional Analytical Meetings
Annual Pharmaceutical Analysis Meeting
Series of Meetings of American Society for Testing Materials
International Symposium of Gas Chromatography
International Symposium on Spectroscopy
International Symposium on Electron Microscopy
Symposium on Microscopy
Analytical Chemical Division of the International Union of Pure and Applied Chemistry

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It is well also to point out that the registered attendance at the Pittsburgh Analytical Symposium has been about 4000 or about one-third that for national ACS Meetings.

The prodigious growth described above can be attributed mainly to the demand by chemical technology for qualitative and quantitative information about the species present in systems. Hence, practically any device or approach capable of measuring a parameter of a chemical system has been quickly adapted for analytical application. The list of specialties quoted from the 1962 Review issue of *Analytical Chemistry* illustrates this point. The growth has been so fast that the demand for analysts and analytical chemists exceeds the supply. As a result, industry has taken many chemists not specifically trained in analysis and allowed them, by direct training or self-training, to become analytical chemists. In my own analytical department there are twelve PhD chemists, of which only six have their degrees in analytical chemistry, three have their degrees in organic chemistry, two in physical chemistry, and one in fuel technology. Of the seven MS men on the staff, three were graduated as analysts, two as physical chemists, one as an inorganic chemist, and one as an organic chemist. This pattern is qualitatively repeated in almost every industrial analytical laboratory. The industrial analytical chemist of any level enjoys the same "status" as his counterparts in synthesis or engineering; he is no longer looked down upon. In fact, it can be generally stated that graduates from schools with recognized analytical curricula are offered salaries 5–10% higher than comparable students in organic synthesis or engineering. It is the principle of supply and demand coming into play. This can be illustrated from the author's experience in personnel recruitment of various types of chemists at the colleges and universities. My average is 15 "synthesis" organic chemists processed per job opening in synthesis research, while only one analytical chemist was processed per job opening (inorganic and engineering recruitment were outside my assignment). This shows the response per job and the scarcity of personnel trained and/or educated in the field of analytical chemistry. In *Chemical and Engineering News* there are many advertisements which specify *analyst or analytical chemist*, and often even the specialty.

The colleges and universities have responded to this surge of analytical activity by augmenting as well as rearranging their curricula. The biggest change has been to move analytical chemistry to a later position in the undergraduate curriculum. The reasoning is that mastery of analytical chemistry as it exists today, requires a knowledge of physical and organic chemistry as well as more advanced mathematics.

It should be added that the content of these analytical chemistry courses has been changed as well as the position in the education time table. No longer is analytical chemistry a "qual-quant" course, it has proceded well beyond volumetric-gravimetric analysis. The courses now include the broad spectrum of tools and knowledge available to solve analytical problems.

Also the number and variety of analytical courses available to the students have increased. Undergraduate courses in instrumental analysis and organic analysis are almost standard offerings. On the graduate level, the training diversifies broadly with some of the analytical specialty areas being covered in separate courses.

It is hoped that the above statistics will serve to put analytical chemistry in the perspective in which it exists today relative to the other chemical technologies. It is also hoped that the emphasis on analytical chemistry in the schools will continue with more schools revamping and augmenting their curricula to provide a better balance of recruits for the chemical field.

An Enrichment Program in Chemistry for the Advanced High School Student

This program for selected high school students who have completed a year of chemistry was designed to enrich backgrounds in chemistry, to increase interest in the science as a professional field, and to prepare them better for collegiate work. It consists of 8 three-hour lecture-discussion-demonstration sessions and 2 four-hour laboratory sessions (syntheses of aspirin and anthraquinone; determination of the half-life of artificially activated indium), all conducted on Saturdays. The overall theme of the program is "the influence of detailed structure on properties," the exact subject coverage having been chosen on the basis of the principal deficiencies in the average high school and introductory college courses.

After considering classical and modern ideas concerning time, position, velocity, and energy, the basic results of quantum mechanics and orbital theory are introduced to enable a systematic building up of the periodic table. Subsequent discussions of the chemical bond (including resonance theory) and crystal structure are concluded by demonstrations of the use of X-ray diffraction equipment and the electron microscope.

A limited number of simple organic compounds—halides, amines, carboxylic acids, esters, phenols, alcohols, nitro compounds—are considered from the standpoint of functional group reactions previous to considering modern concepts of acids and bases. Simple examples of S_N1 and S_N2 mechanisms and a discussion of elementary protein chemistry complete the introduction to organic chemistry. The final session is devoted to the nature of the nucleus and radiochemistry.

Supplementary reading consists of Gamow's *Mr. Tompkins in Wonderland* (Macmillan, 1940), Ryschkewitsch's *Chemical Bonding and the Geometry of Molecules* (Reinhold, *1963*), and five reprints from *Scientific American*. Anyone interested in further details concerning this highly successful program is invited to write the author.

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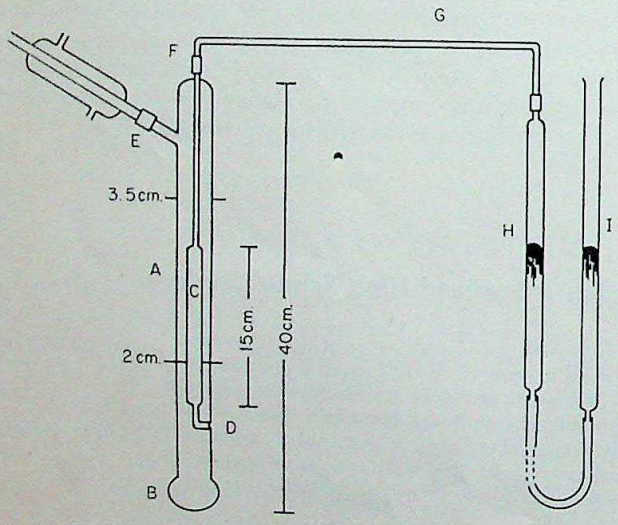
Modified Victor Meyer Apparatus

The determination of vapor density by the Victor Meyer method has long been a useful determination taught in the physical chemistry laboratory. As usually performed, the experiment is rather cumbersome since it involves making and filling sample bulblets, heating a rather large steam jacketed vessel and measuring a displaced volume of air. A student who had had a course in gas chromatography, casually remarked that the sample should be injected with a syringe. The following apparatus was constructed to use a microsyringe for sample introduction and, incidentally, to reduce the size of the equipment and the time required for a determination.

Description of Apparatus. The apparatus consists of a Pyrex glass tube (*A*) about 40 cm long and 3.5 cm in diameter (see Fig. 1). A slight enlargement (*B*) is



Semi-micro Victor Meyer apparatus.

blown on the lower end to receive the liquid which is refluxed to supply a constant temperature jacket. A 15 cm length of 2 cm tubing (*C*) has lengths of 8 mm tubing sealed to each end. The lower length is bent at a right angle and cut to fit inside the jacket. The upper 8 mm tube is secured in the top of the jacket by a ring seal. The lower one is then sealed through the wall of the jacket and the opening (*D*) is tooled to accept a 6 mm silicone puncture type seal or septum. A side-arm (*E*) to receive a small reflux condenser is provided near the top of the instrument. The portion of the instrument between the septum and the condenser side-arm is insulated with a layer of aluminum foil and a layer of loose asbestos cloth.

The upper, or exit, tube (*F*) of the Victor Meyer apparatus is joined by means of a 0.5 mm bore capillary (*G*) to the gas buret (*H*). Short lengths of rubber tubing are used to make the connections. The gas buret has a capacity of 10 ml and may be made conveniently from a 10 ml graduated pipet. The leveling bulb (*I*) is a length of glass tubing of about the same diameter as the pipet. The confining liquid is mercury.

Operation of the Apparatus. A few milliliters of ethylene glycol are added through the condenser side-arm and heated to rapid reflux. The delivery tube (*G*) is detached from the gas buret (*H*), and an aspirator is attached to draw air through the hot apparatus. The delivery tube is replaced, the mercury is leveled, and a silicone seal is pushed into the opening (*D*). A very small funnel made of glass tubing is inserted in the hole in the seal. This enables one to thrust the needle quickly through the septum even though the area around the septum is quite hot. A small syringe needle may be introduced through the septum so that atmospheric pressure is re-established inside the apparatus.

A microsyringe is filled to the desired volume with sample, the usual precautions being taken to eliminate all air bubbles. The end of the needle is closed by thrusting it into a small piece of a silicone plastic and the syringe is weighed. Next, the empty needle is withdrawn from the septum at *D* and the gas buret is read. Then the silicone plug is removed from the syringe needle, the plunger is withdrawn enough to empty the needle back into the syringe body. The needle is thrust through the septum and the sample injected. The leveling bulb is lowered to the correct level. The plunger of the syringe should be withdrawn again to empty the liquid remaining in the needle back into the syringe. The needle is then plugged again and reweighed; the amount of sample vaporized is found by difference. Sample vapor volume is read from the buret. This detailed procedure for introducing the sample is necessary to be sure that all the sample which leaves the syringe—and only that—is introduced inside the apparatus.

The author acknowledges with pleasure the assistance of Arthur P. Ingram and Harry K. Montgomery, Jr., both of the University of Houston, and Kenneth M. Richards, Brevard Junior College, Cocoa, Florida.

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The table illustrates results obtained. In the first series of determinations on methylene chloride two determinations were rejected out of 13, since the deviations were four times the average deviation. The next three determinations are composed of 10 consecutive cases, each with no rejections. The precision of the measurements, indicated in the last column, seems to be as good as the precision of weighing the sample and of measuring the displaced air. A typical sample weighed 0.0413 g as measured on a Type H5 Mettler balance. A typical volume measured 6.43 ml as read in a buret graduated to 0.1 ml.

Summary of Results

Number of cases	Substance	Formula weight	Mol. wt. experimental	Precision
11	CH_2Cl_2	84.94	85.2	85.2 ± 0.5
10	CCl_4	153.84	154.8	154.8 ± 2.9
10	C_6H_6	78.11	78.1	78.1 ± 0.4
10	CCl_4	153.84	153.7	153.7 ± 0.8

In the first two sets of determinations the apparatus was insulated only with aluminum foil. Asbestos insulation was added for the other two sets of determinations.

Static and Kinetic Measurements of an Equilibrium Constant

A physical-inorganic chemistry experiment

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The assumption is often made in discussions of the kinetics of reversible reactions that, since at equilibrium the forward reaction rate equals the back reaction rate, the equilibrium constant must be related to the rate constants for the forward and back reactions. To use a common example

if

$$H_2(g) + I_2(g) \xrightarrow{k_f} 2\ HI(g)$$

and

$$2\ HI(g) \xrightarrow{k_b} H_2(g) + I_2(g)$$

then for any way of writing the balanced equation the associated equilibrium constant is related to these rate constants.

For example,

$$H_2(g) + I_2(g) = 2\ HI(g)$$
$$K = [HI]^2/[H_2][I_2] = k_f/k_b$$

or

$$^1/_2\ H_2(g) + {}^1/_2\ I_2(g) = HI(g)$$
$$K' = [HI]/[H_2]^{1/2}[I_2]^{1/2} = (k_f/k_b)^{1/2}, \text{ etc.}$$

We have felt it desirable in our senior-first year graduate inorganic chemistry laboratory course to include an experiment in which the students can test this assumption by measuring the equilibrium constant directly and comparing this to the equilibrium constant deduced from their own measurement of the kinetics of the forward and back reactions.

There are two particular advantages that we recognize in this experiment. First, it demonstrates an important theoretical point to the student; and second, it provides an experiment, more complex than the usual one, that requires the student to bring together several results and intermediate conclusions, each of which could have been a valid study in itself.

We have chosen the reaction that historically provided the first complete experimental demonstration of the relation between kinetics and equilibrium. Roebuck, (*1*, *2*) studied the reaction

$$H_3AsO_4 + 3I^- + 2H^+ = H_3AsO_3 + I_3^- + H_2O \qquad (1)$$

and found that the forward rate law was

$$\frac{d[I_3^-]}{dt} = k_f[H_3AsO_4][I^-][H^+] \qquad (2)$$

and the back reaction kinetics were given by

$$-\frac{d[I_3^-]}{dt} = \frac{k_b[H_3AsO_3][I_3^-]}{[I^-]^2[H^+]} \qquad (3)$$

His numerical results, as recalculated by Liebhafsky (*3*) in modern units, were, at 0°C

$$K = 6.2\ \text{mole}^{-4}\ \text{liter}^4$$
$$k_f = 1.05 \times 10^{-4}\ \text{moles}^{-2}\ \text{liters}^2\ \text{sec}^{-1}$$
$$k_b = 1.57 \times 10^{-5}\ \text{moles}^2\ \text{liter}^{-2}\ \text{sec}^{-1}$$
$$k_f/k_b = 6.7\ \text{mole}^{-4}\ \text{liter}^4$$

which demonstrate the equivalence of K and k_f/k_b within experimental error. Other work (*4–6*) has confirmed and extended these results although there is still some question (*6*) about the mechanism of the reaction.

The equilibrium constant is determined directly by rapid titration, and the forward and back reaction kinetics are determined by following the formation or disappearance of triiodide ion spectrophotometrically.

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The system is studied at only one temperature, 25°C, in our laboratory, although this could be extended readily to other temperatures if it were felt worth while to spend the time. In order to keep the experiment within reasonable time limits we have allowed the students to take certain things for granted, pointing out to them that this is not possible in an original piece of work. We anticipate for them that the neutral acids H_3AsO_3 and H_3AsO_4 are the important species, and that the possible anions of these acids do not react at a significant rate. Also, we tell them to assume that the order of the reaction is integral with respect to each species and that the absence of fractional orders or of complex reactions can be assumed.

Preliminary Considerations

The Species in Solution. Both H_3AsO_4 and H_3AsO_3 are weak acids, so the *p*H must be kept low in order to ensure that the concentrations of the neutral acids are essentially equal to their formal concentrations. Since K_1 for H_3AsO_4 is 2.5×10^{-4}, and H_3AsO_3 is weaker still, a *p*H lower than 2 will satisfy this condition.

The triiodide ion dissociates to aqueous iodine and iodide ion: at 25°C, moles/liter

$$k_{diss} = 1.4 \times 10^{-3}$$

In order to be able to consider the reaction in the form written above without correcting for the I_2 concentration the free iodide concentration is kept 0.1 *M* or larger.

Ionic Strength. The activities of the various ionic species depend upon the ionic strength and would change appreciably from experiment to experiment as the concentrations are varied. In order to reduce this complication the ionic strength in all stock solutions is made 1.0 *M* by the addition of sodium perchlorate. The fractional change in ionic strength as a result of the reaction is then small and the activity coefficients of the various species remain constant to a good approximation.

Temperature Dependence. The equilibrium constant and the rate constants are temperature dependent. The activation energies for the reactions are 14.1 kcal/mole for the forward reaction (*5*) and 17.0 kcal/mole for the back reaction (*6*). This means that a one degree change in temperature changes the forward and reverse rate constants by factors of 1.08 and 1.10 respectively, a five degree change, by factors of 1.49 and 1.61. In order to make a meaningful comparison of the measured constants all experiments must be made at the same temperature. If the laboratory temperature is not constant to one degree, a constant temperature bath should be used. It is clear from the activation energies that the equilibrium constant is much less temperature sensitive; the correction factors for one degree and five degree changes are 1.02 and 1.09. If temperature variations cannot be avoided the results in each part should be corrected to 25° before they are compared.

The Experiment

In addition to ordinary laboratory glassware, a spectrophotometer is necessary and a constant temperature bath is desirable.

The following solutions are necessary (each number indicates the number of significant figures to which the concentration should be known and not the exact value): 1.000*M* $HClO_4$; 1.000 *M* NaI; 0.150 *M* NaI_3 plus 0.250 *M* NaI in 0.60 *M* $NaClO_4$; 0.500 *M* H_3AsO_4 in 1.00 *M* $NaClO_4$; 0.200 *M* H_3AsO_3 in 1.00 *M* $NaClO_4$; 0.1000 *M* $Na_2S_2O_3$. Note that, except for the thiosulfate, all solutions have ionic strength 1.0 *M*. In all of the parts that follow, unless it specifically states that a rough measurement is being made, accurately known amounts of the various solutions are used although the actual amounts need not agree exactly with those given below.

The Equilibrium Constant. Four solutions with the compositions shown in Table 1 are made up, and are left to equilibrate overnight. After at least 24 hr 25 or 50 ml aliquots are titrated *rapidly* with thiosulfate to the marked lightening of the iodine color. *No starch is used.* It must be realized that the end point is not stable. This method was chosen over a spectrophotometric measurement or equilibrium with an organic solvent to emphasize to the student that if the measurement time is short compared to the reaction time the system does not need to be truly static. From the equilibrium amount of iodine, assumed to be in the form I_3^-, the concentrations of all species, and thence the equilibrium constant, can be calculated.

Table 1. Molar Concentrations in Solutions Used for Equilibrium Measurements

	$[H^+]$	$[I_3^-]$	$[I^-]$	$[H_3AsO_4]$	$[H_3AsO_3]$
S-1	0.3	...	0.4	0.06	...
S-2	0.2	0.06	0.2	...	0.06
S-3	0.2	...	0.5	0.04	...
S-4	0.1	0.04	0.4	...	0.04

Table 2. Molar Concentrations in Solutions Used for the Forward Reaction Measurements

	$[H_3AsO_4]$	$[I^-]$	$[H^+]$
S-5	0.01	0.2	0.4
S-6	0.01	0.4	0.1
S-7	0.02	0.2	0.2
S-8	0.02	0.4	0.1
S-9	0.04	0.1	0.2
S-10	0.04	0.1	0.4
S-11	0.08	0.1	0.1
S-12	0.08	0.2	0.1

The Kinetics of the Forward Reaction. The order of the forward reaction with respect to the various species is first determined in a qualitative experiment. Eight solutions, of the compositions shown in Table 2, are prepared by adding the previously measured volume of iodide solution from eight beakers to the previously mixed acid, arsenic acid, and diluting water, as nearly simultaneously as possible. Triiodide is formed in all the solutions immediately and after a minute or two they are arranged in order of their intensities and the order recorded. The initial rate is

$$\frac{d[I_3^-]}{dt} = [H_3AsO_4]^x[I^-]^y[H^+]^z$$

and, as can be seen from the concentrations used, the initial rates should all be the same or different by powers of two if x, y and z are integers as the students have been told to assume. An inspection of the order of increasing rates, which is ideally

$$6 < 5 \sim 7 \sim 8 \sim 9 \sim 11 < 10 \sim 12$$

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allows the choice $x/y/z = x/x/x$ to be made. Since the students are told to choose the smallest set of integers that satisfy the ratio, 1/1/1 is chosen. For any other ratio of $x/y/z$ a quite different order would obtain, and even though the students do not get all solutions correctly ordered (they usually tend to judge differences too closely) the 1/1/1 ratio gives the most consistent agreement.

In preparation for the spectrophotometric determination of the rate constants the students determine the extinction coefficient of triiodide as a function of wavelength from 400–600 mμ, and choose a wavelength at which the optical density of a 10^{-3} M solution in a 1 cm cell is about 0.5 for use in all the kinetic measurements.

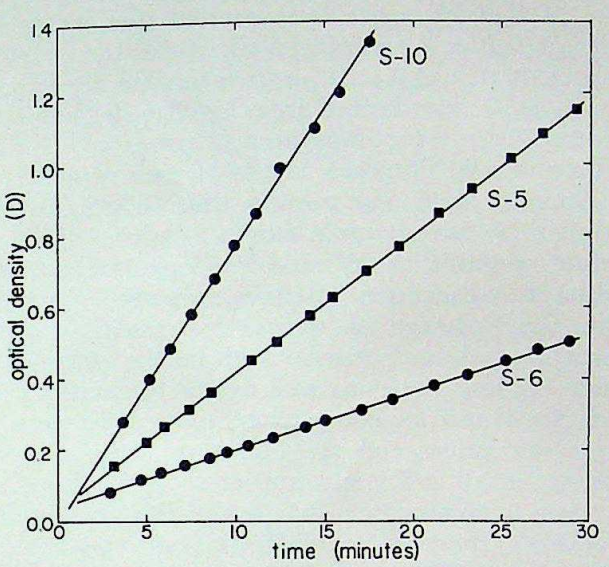

Figure 1. Optical density versus time for the forward reaction (475 mμ). From the slopes the following rate constants were calculated (in moles^{-2} liter^2 sec^{-1}):

S-5 $k_f = 1.59 \times 10^{-3}$
S-6 $k_f = 1.31 \times 10^{-3}$
S-10 $k_f = 1.57 \times 10^{-3}$

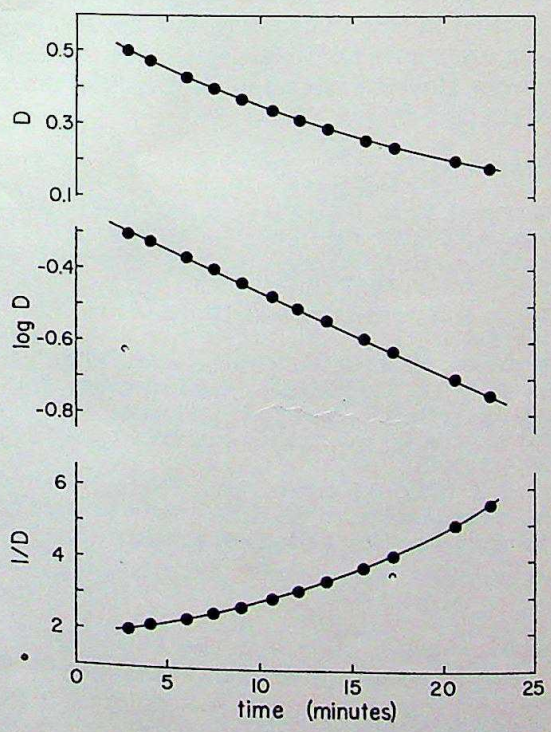

Figure 2. Determination of the order of the back reaction with respect to (I_3^-). The optical density, the log of the optical density, and the reciprocal of the optical density are plotted against time. The linearity of the log plot indicates a first order reaction.

When a suitable wavelength has been determined, three of the solution compositions from Table 2 are selected for the accurate kinetic measurements. These solutions are made up accurately this time, with the time of mixing carefully noted, and readings of the optical density are taken every 1–2 minutes until the optical density is between 0.5 and 1.0; usually this requires about 30 minutes. The three solutions plus a blank solution can all be accommodated in the spectrophotometer cell holder (Beckman Model DU or Model B) so that all of these readings can be taken during the same period of time.

The conditions chosen here are such that no appreciable amount of the reactants is used up; thus the right side of equation 2 can be assumed constant. The slope of a plot of (I_3^-) or of the optical density, D, versus time then allows the rate constant to be calculated in a straightforward way. Figure 1 shows a typical set of results for this part of the experiment.

The Kinetics of the Back Reaction. As with the forward reaction both the form of the rate equation and the value of the rate constant are to be determined. The rate is given by

$$-\frac{d[I_3^-]}{dt} = k_b[H_3AsO_3]^s[I_3^-]^t[I^-]^u[H^+]^v$$

where s, t, u, and v are assumed to be integers. In the study of this rate law quantitative measurements are made immediately, but otherwise the approach is similar to the study of the forward reaction. The triiodide concentration is followed spectrophotometrically as a function of time in six solutions of the compositions shown in Table 3. The reactions are followed for about 20 min by which time at least half of the original triiodide concentration has been used up. Of the species whose concentrations appear in the rate law only the concentration of triiodide ion changes appreciably during the course of the reaction. Therefore, the dependence of rate on (I_3^-), i.e., the exponent t, can be determined directly from a change of (I_3^-) with time. One run is chosen to determine the value of t and plots of D, log D, and $1/D$ versus t are drawn. (The triiodide concentration could be used rather than the optical density, but this involves a considerable amount of unnecessary conversion.) Typical plots of results are shown in Figure 2.

When the correct dependence of (I_3^-) has been decided upon the student plots all six runs on the appropriate plot, and by an inspection of the slopes decides upon the values of s, u, and v. A typical set of curves is shown in Figure 3. From the slopes and the values of the initial concentrations a value of k_b can be calculated for each of the six solutions.

Table 3. Molar Concentrations in Solutions Used for the Back Reaction Measurements

	$[H_3AsO_3]$	$[I_3^-]$	$[I^-]$	$[H^+]$
S-13	0.1	1×10^{-3}	0.3	0.1
S-14	0.05	1×10^{-3}	0.3	0.1
S-15	0.1	1×10^{-3}	0.15	0.1
S-16	0.1	1×10^{-3}	0.3	0.05
S-17	0.1	2×10^{-3}	0.3	0.1
S-18	0.05	2×10^{-3}	0.15	0.2

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Table 4. Experimental Results at 25°C—Student Laboratory and Literature

Source	K (moles/l)$^{-4}$	$k_f \times 10^3$ (moles/l)$^{-2}$ sec^{-1}	$k_b \times 10^5$ (moles/l)^2 sec^{-1}	k_f/k_b
Average of 8 expts	24.5 ± 1.5	1.37 ± 0.10	6.40 ± 0.72	21.4 ± 2.9
Best student work	22.9 ± 2.5	1.47 ± 0.15	6.98 ± 0.35	21.1 ± 2.4
Poorest student work	34.2 ± 12.3	1.44 ± 0.22	5.15 ± 0.55	28.0 ± 5.2
Literature (at low ionic strength)	18.2 (ref. (7))	1.18 (ref. (5))	6.5 (calc.)	... ...

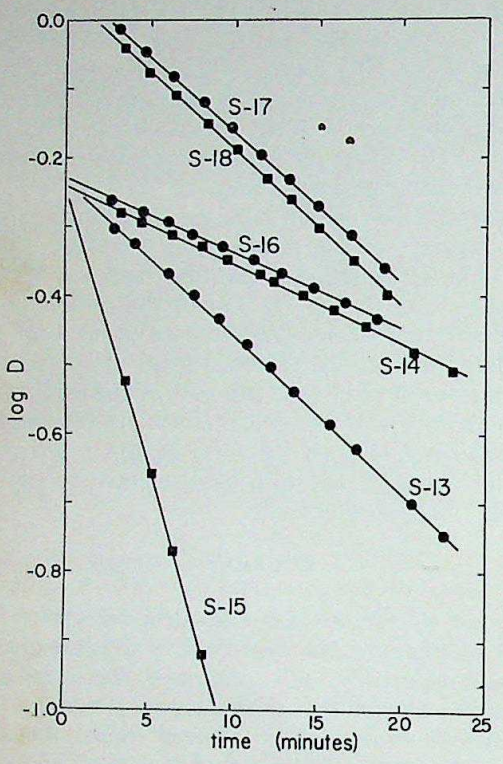

Figure 3. Log optical density versus time for the back reaction (475 mμ). From the slopes the following rate constants were calculated (mole^2 liter^{-2} sec^{-1}):

S-13 $k_b = 7.38 \times 10^{-5}$
S-14 $k_b = 7.08 \times 10^{-5}$
S-15 $k_b = 6.66 \times 10^{-5}$
S-16 $k_b = 6.54 \times 10^{-5}$
S-17 $k_b = 6.81 \times 10^{-5}$
S-18 $k_b = 7.23 \times 10^{-5}$

(The acid concentration in S-16 was four times that given in Table 3.)

Results and Discussions

At this point the student has determined four values of the equilibrium constant, three values of the forward rate constant, and six values of the back rate constant. He is therefore in a position to calculate a mean value for each constant, and to estimate the error of his measurement. At the option of the instructor a careful error analysis can be made, or the average deviations of a given student's results can be used as a measure of their accuracy.

In Table 4 are shown some results from our most recent group of undergraduates. Eight pairs of students did the experiment. The results of the best pair (best as judged from internal consistency and from other evidence of careful work) and the worst pair and the average results of the entire class, are shown. The averages were weighted according to the average deviations of the individual data, so that, for example, a value of 25.0 ± 2.0 was given four times the weight of a value 22.0 ± 4.0. All error estimates are average deviations, or are derived from average deviations by the usual formula for propagation of error (*7*).

There are no literature values at ionic strength 1.0 to compare with our results, but Washburn and Strachan (*8*) have made a careful study of the equilibrium constant at 25° and low ionic strength, and Wilson and Dickinson (*5*) have measured k_f at 25° from the exchange of radioactive arsenic between arsenious acid and arsenic acid in the presence of iodide. These values as well as the calculated value of k_b are shown for comparison. The differences between our values and the literature values are surprisingly small and might appear to be in the wrong direction to be accounted for by the difference in ionic strengths. However, consideration of equation (1) shows that hydrogen iodide provides a reasonable model compound for ionic strength effects in this system, and the mean activity coefficient for hydrogen iodide solutions is nearly 1 at ionic strength 1.0 (*9*).

Acknowledgments

We should like to thank the teaching assistants who have assisted in this course over the last several years for their comments and criticisms. We are indebted to Professor Robert Livingston for a helpful discussion of ionic strength effects.

Literature Cited

(1) Roebuck, J. R., *J. Phys. Chem.*, **6**, 365 (1902).
(2) Roebuck, J. R., *J. Phys. Chem.*, **9**, 727 (1905).
(3) Liebhafsky, H. A., *J. Phys. Chem.*, **35**, 1648 (1931).
(4) Bray, W. C., *J. Phys. Chem.*, **9**, 578 (1905).
(5) Wilson, J. N., and Dickinson, R. G., *J. Am. Chem. Soc.*, **59**, 1358 (1937).
(6) Liebhafsky, H. A., *J. Am. Chem. Soc.*, **61**, 3515 (1939).
(7) Livingston, R. L., "Physico Chemical Experiments," *3rd* ed., Macmillan Co., New York, 1957, p. 22.
(8) Washburn, E. W., and Strachan, E. K., *J. Am. Chem. Soc.*, **35**, 681 (1913).
(9) Lewis, G. N., and Randall, M., "Thermodynamics," 2nd ed. revised by Pitzer, K. S., and Brewer, L., McGraw-Hill Book Co., New York, 1961, p. 645.

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A dynamic method for Measuring Dissociation Pressures

Measurements of dissociation pressures have long been of interest, both from the fundamental and practical viewpoint. Although each material under study requires some special consideration, a host of materials dissociate into products where one of them is in the gaseous state, e.g.,

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

For such systems various techniques have been employed with the most widely used corresponding to a static vapor pressure measurement. This communication reports a simple and rapid method based on the thermogravimetric principle in a controlled atmosphere yielding equilibrium dissociation pressures.

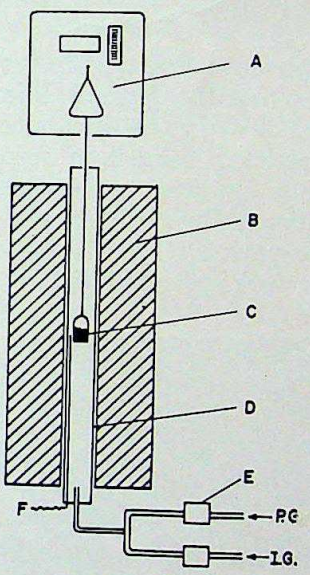

Figure 1. Thermogravimetric system for dissociation pressure measurements: *A*, balance with optical scale; *B*, furnace; *C*, sample crucible; *D*, furnace tube; *E*, flow-meters; *F*, thermocouple to recorder; *P.G.*, product gas; and *I.G.*, inert gas.

The essential equipment consists of a furnace, a balance, preferably a single pan type with an optical scale, flow-meters and a temperature monitoring device. The system arrangement is shown in Figure 1. For evaluation of the technique $CaCO_3$ was used. In brief, the following procedure was adopted. A crucible containing reagent grade $CaCO_3$ was freely suspended inside a furnace tube from a precision analytical balance featuring an optical scale (100 mg range). The tube presenting a closed system had a bottom gas inlet and a small hole on top serving for the free passage of the suspension wire and as gas outlet. A thermocouple was positioned as near as possible to the suspended sample without making actual contact. A desired partial pressure of CO_2 was established in the tube by monitoring the flow rates of predried N_2 and CO_2. The total pressure of the gas stream at all times was equal to atmospheric pressure. With the CO_2 pressure fixed, the furnace was heated and temperature and weight changes were monitored. When the sample temperature exceeded the equilibrium temperature for the fixed CO_2 pressure, the sample weight decreased corresponding to a loss of CO_2 and the formation of CaO. The temperature was then decreased until the reverse reaction took place and the sample weight began to increase. By cycling the temperature several times through the temperature at which no weight change occurred, it was possible to determine the true equilibrium temperature within 1°C for the particular fixed CO_2 pressure. Since the gas flow rates are readily adjustable, the equilibrium pressures can be measured up to one atmosphere. The results on $CaCO_3$ indicate a dissociation pressure of one atmosphere at 899°C which is well within the limits of 895 to 902°C reported more recently in the literature.[2,3] Results are shown in Figure 2 for measurements on $CaCO_3$, Li_2CO_3, and Na_2CO_3. For the latter two, where the systems are molten, the rates of weight gain or loss are less than for $CaCO_3$, undoubtedly because of the greatly decreased surface areas presented by the melts.

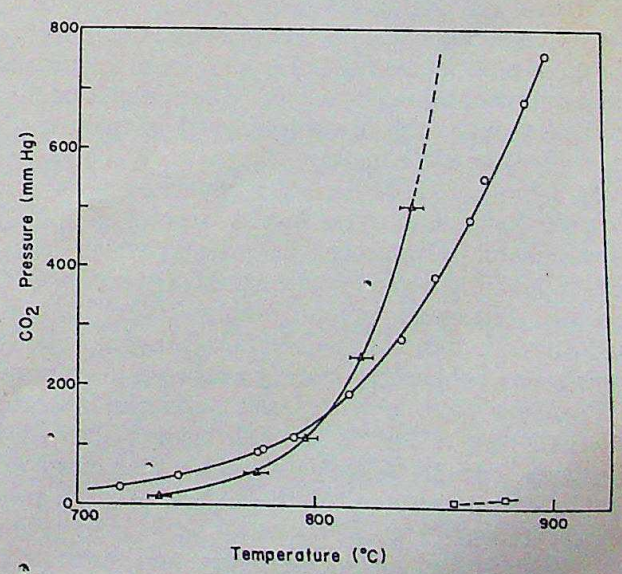

Figure 2. Dissociation pressures: —○—○—, $CaCO_3$–CaO; —△—△—△—, Li_2CO_3 (mp 710°C)-Li_2O; —□—□—, Na_2CO_3 (mp 858°C)-Na_2O.

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[1] Present address: General Electric Company, Research Laboratory, Schenectady, New York.

[2] Hill, K. J., and Winter, E. R. S., *J. Phys. Chem.*, 60, 1361 (1956).

[3] Baker, E. H., *J. Chem. Soc. London*, 1962, 464.

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The present method has several advantages over other techniques, some of which warrent mention. The dynamic method is simple and rapid and requires equipment which is standard in most laboratories. Equilibrium pressures of the product gas are measured truly. The results are independent of the presence of any small impurity phase which on heating may also yield a gaseous product, e.g., H_2O vapor. The technique has been used successfully for solids and liquids in this laboratory. The method is especially useful in cases where at times weeks are required before total equilibrium is reached. For instance, in the static dissociation pressure measurement of $CaCO_3$ it took three weeks to reach equilibrium at 450°C and several hours at 800°C.[2] By nature of the dynamic method the same results are attained in the order of an hour or less depending mainly on the maintenance of thermal equilibrium in the temperature cycling.

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William Allen Miller: Pioneer Stellar Spectroscopist

The practice of naming lunar formations after celebrated scientists, philosophers, and theologians was first instituted in 1651 by the Jesuit astronomer Riccioli. The system has not only survived until the present day but has grown so that there are several hundred formations thus identified. Included in the list of the honored are eleven chemists: Berzelius, Boussingault, Cavendish, Davy, Klaproth, Lavoisier, Liebig, Miller, Regnault, Wöhler, and Wollaston. The names of most of these men are familiar and their achievements are recorded in the standard works on chemical history. William Allen Miller, an eminent scientist in his own day seems, however, to have slipped into obscurity in ours.

Miller was born December 17, 1817, at Ipswich, in Suffolk County, England. His taste for the sciences was acquired during his two years at Ackworth, a school belonging to the Society of Friends, in Yorkshire. Here, in addition to attending occasional lectures and demonstrations in chemistry, Miller was sometimes invited to view the heavens through a telescope belonging to one of the masters.

At the age of 15, Miller was apprenticed to his uncle, Bowyer Vaux, a surgeon in the General Hospital at Birmingham. It was this hospital in which Miller's father served as secretary for nearly 20 years. At the end of a five-year apprenticeship Miller became a medical student in King's College in London. Here his knowledge of chemistry quickly attracted the attention of Professor J. F. Daniell; and when the laboratory assistant was taken ill, Daniell used Miller as his substitute. In 1839 Miller won the Warneford prize for the encouragement of theological studies among medical students.

In 1840 Miller visited Germany and spent a few months in Liebig's laboratory at Giessen. Upon his return to London he was appointed to the post of demonstrator in the laboratory of King's College. In 1841 he was appointed assistant lecturer to Professor Daniell, and also took the degree MB in the University of London, the MD degree being attained the following year. Miller assisted Daniell in research problems, and in 1844 they appeared as co-authors of a paper entitled "Additional Research on the Electrolysis of Secondary Compounds" (*1*), an outgrowth from Daniell's earlier work in electrolysis.

William Allen Miller

In 1845 Miller was elected a Fellow of the Royal Society. The same year saw him appointed to the chair of chemistry in King's College, vacant because of the sudden death of Daniell.

In this capacity Miller continued studies in the field of spectroscopy. The first of what was to be a long series of papers in this area was presented to a meeting of the British Association for the Advancement of Science at Cambridge in 1845, and published in the

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Philosophical Magazine (*6*). Continuing a line of work begun by Sir David Brewster and extended by Daniell, Miller attempted to unravel the mysteries of the Fraunhofer lines in the solar spectrum.

In addition to the series of papers on spectral studies, Miller took a strong interest in the examination of water and in 1865 published a series of proposed standard methods to bring order out of chaos in this field (*5*). His work was not, however, confined to these two fields. No less than 21 papers bearing his name and dealing with a wide variety of subjects attest to the diversity of his interests.

An active member of the Bristish Association for the Advancement of Science, he served two terms as secretary of its Chemistry and Mineralogy section, five terms as its vice-president, and three as president. With the exception of 1852 he was a member of the Council of the Association from 1851 to 1869. He also served on a number of its committees investigating scientific problems.

Stellar Spectroscopy

Miller's most significant work, and that for which he received the greatest honor, began in January of 1862 following the delivery of a lecture on spectrum analysis to the Pharmaceutical Society of London. The meeting had been attended by the astronomer William Huggins, Miller's friend and neighbor; and on the homeward journey Huggins suggested a plan to use his telescope in conjunction with Miller's spectroscope to study the spectra of the celestial bodies. This fortunate union was to bring forth several "firsts" for the two scientists. In 1864 papers were presented to the Royal Society (*2, 3*) and the Brisish Association for the Advancement of Science (*7*) reporting the first attempt to determine the elements present in stars by spectral analysis. The spectroscope had been so constructed that a reference spectrum of the element being sought could be placed in juxtaposition with the stellar spectrum. In this manner the presence of the element could be proved by the exact coincidence of the lines of two the spectra rather than by an approximation of positions required by other methods. During the course of the investigation the spectra of some 20 of the brighter stars in the sky were studied, and the frequency of the appearance of the lighter elements was noted.

On the basis of these observations they concluded that,

> The differences which exist between stars are of the lower order, of differences of particular adaptation, or special modification, and not differences of the higher order of distinct plan of structure. There is therefore a probability that these stars, which are analogous to our sun in structure, fulfil an analogous purpose, and are, like our sun, surrounded by planets, which they by their attraction uphold, and by their radiation illuminate and energize. . . . It is remarkable that the elements most widely diffused through the host of stars are some of those most closely connected with the constitution of the living organisms of our globe, including hydrogen, sodium, magnesium, and iron. . . . On the whole we believe that the foregoing spectrum observations on the stars contribute something toward an experimental basis on which a conclusion, hitherto but a pure speculation, may rest, viz., that at least the brighter stars are, like our sun, upholding and energizing centres of systems of worlds adapted to be the abodes of living beings.

Studies were also made of the spectra of the moon and the planets, and evidence was presented that the atmospheres of Saturn, Jupiter, and Mars were quite different from that of the earth, while the moon was found to be without an appreciable atmosphere.

In May of 1866 the star now known at T *Coronae Borealis* rose, in a matter of a few hours, from an invisible magnitude of 9.5 to a bright magnitude 2, and then slowly faded back to obscurity. Four nights after the outburst the star was still at third magnitude, and the spectrum was examined by Miller and Huggins and reported to the Royal Society the following day.

> When the spectroscope was placed on the telescope, the light of this new star formed a spectrum unlike that of any celestial body which we have hitherto examined. The light of the star is compound, and has emanated from two different sources. Each light forms its own spectrum. In the instrument these spectra appear superimposed. The principal spectrum is analogous to that of the sun, and is evidently formed by the light of an incandescent solid or liquid photosphere, which has suffered absorption by the vapours of an envelope cooler than itself. The second spectrum consists of a few bright lines, which indicates that the light by which it is formed was emitted by matter in the state of a luminous gas. . . . The character of the spectrum of this star, taken together with its sudden outburst in brilliancy and its rapid decline in brightness, suggests to us the rather bold speculation that, in consequence of some vast convulsion taking place in this object, large quantities of gas have been evolved from it, that the hydrogen present is burning by combination with some other element and furnishes the light represented by the bright lines, also that the flaming gas has heated to vivid incandescence the solid matter of the photosphere. As the hydrogen becomes exhausted, all the phenomena diminish in intensity, and the star rapidly wanes (*4*).

For their studies in this field the Royal Astronomical Society presented its Gold Medal to Huggins and Miller in 1867. It was necessary upon this occasion to suspend the bylaws of the Society to permit the award of the Medal to Miller, as he was not a member of the Society (*8*). Huggins had received the Gold Medal of the Royal Society in 1866, but Miller's position as vice-president and treasurer of the Society, and his consequent membership on its Council, forbade any consideration of his participation in the award (*9*).

Miller was one of the founding members of The Chemical Society, serving as a vice-president for five years, and president in 1855–6 and 1865–6, as well as a member of its Council from its founding until 1870. Many honors come to him, including honorary LLD degrees from the Universities of Edinburgh and Cambridge, an honorary DCL from Oxford, and an appointment as Assayer of the Mint and of the Bank of England. Following a brief illness, Miller died in September of 1870 at the age of 53.

Literature Cited

(1) Daniell, J. F., and Miller, W. A., *Phil. Trans. Roy. Soc. London*, **134**, 1 (1844).

(2) Huggins, W., and Miller, W. A., *Phil. Trans. Roy. Soc. London*, **154**, 413 (1864).

(3) Huggins, W., and Miller, W. A., *Proc. Roy. Soc. London*, **12**, 444 (1865).

(4) Huggins, W., and Miller, W. A., *Proc. Roy. Soc. London*, **15**, 146 (1866).

(5) Miller, W. A., *Brit. Assoc. Advancement Sci., Rept.*, **1845**, 28.

(6) Miller, W. A., *J. Chem. Soc.*, **18**, 117 (1865).

(7) Miller, W. A., and Huggins, W., *Brit. Assoc. Advancement Sci., Rept.*, **1864**, 12.

(8) Prichard, C., *Monthly Notices Roy. Astron. Soc.*, **27**, 146 (1867).

(9) Sabine, E., *Proc. Roy. Soc. London*, **15**, 270 (1866).

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Chem Ed

BOOK REVIEWS

Elementary Quantitative Analysis

W. J. Blaedel and *V. W. Meloche*, both of the University of Wisconsin, Madison. 2nd ed. Harper and Row, Publishers, New York, 1963. xi + 964 pp. Figs. and tables. 16.5 × 23.5 cm. $9.60

An excellent text has been improved in this Second Edition, although the review of the First Edition (J. CHEM. EDUC., **34**, A283 [1957]) could be repeated almost verbatim. The most important change is the addition of an extensive chapter on Complexation Titrations. The authors are to be commended on their development of complex equilibria and their graphic presentation of the advantages of chelons in analytical chemistry.

Other major changes include: addition of an experiment on potentiometric determination of chloride, addition of a large number of questions and problems to an already impressive collection, exclusive use of the Brønsted treatment in acid-base equilibria (formerly in Supplement), and expansion and updating of the literature references.

Minor changes include: use of larger type for headings, removal of asterisks from more difficult problems (confusion remains with two or more problems on the same page with the same number), numerical changes in the data in many problems, revision of material on growth of crystals and purity of precipitates, balancing of redox equations with half reactions (formerly in Supplement), addition of material on mechanism of redox reactions to the Supplement, omission of the quinhydrone electrode, emphasis on spectrophotometry instead of simple colorimetry, etc.

In spite of these obvious improvements, this reviewer feels more critical of this edition than the first. It is now six years later, and we are still assumed to be teaching essentially the same material as 20 years ago. In other divisions of chemistry, radically new approaches have appeared which reflect the advance of chemistry. While this book is at the top of the list of traditional texts, it fails to give an adequate presentation of current analytical chemistry. For example, the table on page 13, "A Survey of Analytical Publications on Various Methods of Measurements," is out of date. Yet the balance of emphasis in this text is even farther behind the times. With over 900 pages at their disposal and a wealth of other texts to improve upon, the authors might have produced a masterpiece—and they have! But in 1963, why are visible spectrophotometry, potentiometry, and complexation titrations still relegated to "Special Topics"? Where are ion exchange, solvent extraction, various kinds of chromatography, ultraviolet and infrared spectrophotometry, electrochemical methods, radio-counting techniques? The argument for their omission given by the authors in Chapter 22 is not convincing. On page 540, methods based on thermal properties (e.g., DTA and GC detectors) are dismissed with the notation, "not frequently used, but frequently valuable"—the same statement made in the first edition. At this level one does not expect an exhaustive treatment, but there must be some overview of all analytical techniques and the kinds of information they can supply other than straight forward analysis of samples. This is especially true as the time devoted to analytical chemistry must diminish and most students will not take another analytical course.

The above remarks apply to most of the recent texts on elementary analysis. This is a superb source of information for the limited area it is intended to cover, and will be welcomed by all teachers who are giving a traditional course at the sophomore level.

ROBERT L. PECSOK
University of California
Los Angeles

Fundamentals of Analytical Chemistry

Douglas A. Skoog, Stanford University, Stanford, California, and *Donald M. West*, San Jose State College, San Jose, California. Holt, Rinehart, and Winston, New York, 1963. xii + 786 pp. Figs. and tables. 15.5 × 23.5 cm. $8.50.

This text is aimed primarily at sophomore-level chemistry students, and stresses "an appreciation for the over-all analytical process." The book consists of two major portions. The first includes topics generally considered as classical analytical methods, containing sections entitled Introduction, Gravimetric Analysis, and Volumetric Analysis, and accounts for about two-thirds of the book. The remaining portion of the book treats electrical and optical methods of analysis, and several miscellaneous topics, including sampling, attack of samples, and separations. Although the preface states the authors aim to emphasize similarities between classical and instrumental methods, there is very little connection between these two main sections of the book.

In general, the book stresses practical techniques and analytical calculations rather than fundamental chemical principles. The approach has been to compile a large number of determinations and reactions, but to discuss few in any detail. For example the book contains a most comprehensive listing of determinations based on oxidation-reduction titrations, including those based upon titrants such as bromate, periodate and chromous ions. On the other hand, the induced reaction of chloride ion and permanganate during the well-known titration of iron is only mentioned, induced reactions are not defined, and the mechanism of the reaction and the function of the Zimmermann-Reinhardt solution are not discussed. Titrations based on complex-formation reactions are described, including the use of EDTA as a titrant, but only two pages are devoted to a discussion of what a complex ion is, how it is formed, chelate compounds, instability constants,

Reviewed in this Issue

W. J. Blaedel and *V. M. Meloche*, Elementary Quantitative Analysis
Douglas A. Skoog and *Donald M. West*, Fundamentals of Analytical Chemistry
P. W. West, A. M. G. MacDonald and *T. S. West*, editors, Analytical Chemistry, 1962
John C. Slater, Quantum Theory of Molecules and Solids. Volume 1, Electronic Structure of Molecules
Harry H. Heckman and *Paul W. Starring*, Nuclear Physics and the Fundamental Particles
John W. Sulcoski and *Stephen Rituper*, Basic Chemistry Problems for High School
I. Prigogine, editor, Advances in Chemical Physics. Volumes 4 and 5
Koji Nakanishi, Infrared Absorption Spectroscopy
M. F. Lappert and *G. J. Leigh*, editors, Developments in Inorganic Polymer Chemistry
John K. Stille, Introduction to Polymer Chemistry
W. R. Moore, An Introduction to Polymer Chemistry
James L. Fairley and *Gordon L. Kilgour*, Essentials of Biological Chemistry
John G. Hawthorne and *Cyril S. Smith*, translators, On Divers Arts: the Treatise of Theophilus
Ernst Jucker, editor, Progress in Drug Research. Volume 4
B. L. Horecker, Pentose Metabolism in Bacteria
Paul Pascal, editor, Nouveau Traité de Chimie Minerale. Volume 20, Alliages Métalliques, Part 2

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etc. The discussion of equilibria calculations and especially acid-base titration curves is very good, although the use of Arrhenius (hydrolysis) rather than Brønsted concepts in the calculations is disappointing.

The second portion of the book is intended for a second semester course, but really only covers a portion of what is modern instrumental analysis. This reviewer, an electroanalytical chemist, questions the prevailing practice of writers of elementary quantitative analysis texts of devoting a large portion of their books to the relatively complex subject of electroanalytical chemistry, to the almost complete exclusion of many easily understood and widely used techniques. For example this text devotes 126 pages to electroanalytical methods, but only two pages to gas chromatography. Some of the more esoteric topics, such as differential potentiometric titrations and kinetic and catalytic currents in polarography, might have been left to monographs. Similarly discussions of overpotential and diffusion presented to students before they have had physical chemistry, seems unwise.

The book contains about 400 problems and numerous references to the literature, including a good brief description of the literature of analytical chemistry. In general the book is carefully and clearly written with few errors of fact. One misstatement repeated several times concerns the standard potential of the standard hydrogen electrode, which is defined as zero at all temperatures, not only at 25°. The figures are good, and the price seems reasonable. The book certainly deserves consideration as a text for a course stressing practical analytical chemistry and a detailed survey of analytical methods.

Allen J. Bard
University of Texas
Austin

Analytical Chemistry, 1962: The Proceedings of the International Symposium held at Birmingham University, April, 1962.

Edited by *Philip W. West*, Louisiana State University, Baton Rouge, and *A. M. G. MacDonald* and *T. S. West*, University of Birmingham, England. American Elsevier Publishing Co., New York, 1963. x + 411 pp. Figs. and tables. 17 × 24.5 cm. $16.

The 1962 International Symposium on Analytical Chemistry was held in honor of Fritz Feigl to commemorate his 70th birthday. For this reason, a considerable portion of the meeting was devoted to spot test and the role of organic reagents in analytical chemistry. The papers in this area vary in scope and treat such general topics as oxidation potentials in qualitative analysis or specific subjects such as Vic-Dioximes as analytical reagents. Some papers dealing with spot analysis seem to be designed to discuss the present status of a general area such as the detection of pharmaceutical products by spot test reactions.

There are sections of this work which deal with subjects such as electrochemical, radiochemical, and optical methods of analysis. Topics of current interest such as atomic absorption spectroscopy, differential electrolytic potentiometry, and cathode ray polarography are treated by outstanding research workers in these fields.

There are small sections dealing with separation processes and titrimetric analysis and miscellaneous topics.

Although the papers, of necessity, are short coupled with the printed discussion of the paper, they are quite worthwhile. This book will be most useful as a library reference for persons attempting to catch up on the recent developments during the past two years in the areas mentioned.

Theodore R. Williams
College of Wooster
Wooster, Ohio

Quantum Theory of Molecules and Solids. Volume 1, Electronic Structure of Molecules

John C. Slater, MIT. McGraw-Hill Book Co., Inc., New York, 1963. Figs. and tables. xv + 485 pp. 16.5 × 23.5 cm. $12.50.

This book represents a further installment of Professor Slater's magnum opus, a general account of the quantum theory of atoms, molecules, and solids. Having treated atomic structure in a two-volume work which appeared in 1960, he has now embarked on an account of the quantum theory of molecules. This volume, the first of the new series, deals with the methods currently available for treating molecular structure, and with their application to some specific problems.

The general construction of the book follows a conventional pattern. The first four chapters deal with the hydrogen molecule and molecule ion, the fifth describes the MO method including the Roothaan SCF treatment, the next two chapters discuss homonuclear and heteronuclear diatomic molecules, chapter eight deals with group theory and symmetry properties of wave functions, chapter nine with Bloch's method for constructing symmetry orbitals together with an introduction to the theory of solids, and the last three chapters deal with ammonia, methane, water, ethylene, and benzene.

The appearance of any book by Professor Slater is always a notable event; there is really no need for the reviewer to say more about this one than that it is well up to his highest standards. It is concise, clear, stimulating, and (as one would expect) full of original ideas and observations; it is also a joy to read. Much of this clarity comes from its construction; the main text occupies little more than half the book, being followed by 146 pages of appendices dealing with mathematical details, ranging from the Virial Theorem and Group Theory to the calculation of molecular integrals. As a bonus there is an extremely comprehensive 80-page bibliography which alone would be worth the price of the whole book—which in any case is most reasonable.

This book is a "must" for anyone with any interest in quantum chemistry. One can only hope that the following volumes will appear in quick succession and that they will be equally good—they could hardly be better.

Michael J. S. Dewar
University of Chicago
Chicago, Illinois

Nuclear Physics and the Fundamental Particles

Harry H. Heckman, Lawrence Radiation Laboratory, University of California, Berkeley, and *Paul W. Starring*, Lodi High School, Lodi, California. Holt, Rinehart, and Winston, Inc., New York, 1963. vi + 410 pp. Figs. and tables. 15.5 × 23.5 cm. Paperbound. $0000.

This paper-back volume for "capable high school students" was written at the request of a group of teachers who had participated in the summer lecture-research program at the Lawrence Radiation Laboratory of the University of California. Many of these teachers felt there was a great need for a text written for high school students which would "both recast and elaborate on the subject of the physics of the nucleus and the fundamental particles." Physicist Heckman of the Lawrence Radiation Laboratory and high school teacher Starring have teamed up to collect in a single volume, a body of information which has hitherto been available largely in college texts on nuclear physics or in the periodical and research literature.

In the opinion of the reviewer the *average* high school student will find this volume difficult. On the other hand the capable student with a good grasp of mathematics will breeze through it and wish that the authors had filled in the gaps in spots where they have indicated, "Using the calculus it is possible to show that . . . ."

The treatment is then, essentially nonmathematical, meaning that only algebraic arguments are used. There is an obvious temptation on the part of the authors to lapse into a bit of calculus here and there, but on the whole they have shown remarkable restraint.

The early chapters deal with atomic structure, basic properties of nuclei and nuclear models, followed by radioactive nuclei, interactions of radiation with matter, particle accelerators and detection of radiation. The next few chapters deal with unstable particles (neutrons, pions, and muons), with strange particles (K mesons and hyperons) and with antiparticles. Finally there are chapters on space physics (cosmic rays and the Van Allen belts) and health physics.

Each chapter has a set of review questions, as well as work problems and calculations. Answers are given to alternate problems. The Appendix includes a glossary of units, symbols and abbreviations, a table of physical constants and conversion factors, and a table of fundamental particles. A table of isotopic masses is not included.

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The authors have preferred a tight, terse style. While this permits more efficient coverage of the field, some chapters tend to be encyclopedic and dry (e.g., Unstable Particles, Antiparticles). Elsewhere in the volume use of historic anecdote has provided some of the "spice" which is so often needed to keep a strictly factual diet palatable.

All in all the work is commendable and should provide the keen high school student and many a high school teacher an excellent summary of the nuclear field.

DONALD S. ALLEN
State University of New York
Albany

Basic Chemistry Problems for High School

John W. Sulcoski, Dallas Senior High School, Dallas, Pennsylvania, and *Stephen Rituper*, Liberty High School, Bethlehem, Pennsylvania. Burgess Publishing Co., Minneapolis, Minnesota, 1963. v + 216 pp. Figs. and tables. 15 × 23 cm. Paperbound. $2.75.

The attempt of the authors to construct a problem book of basic problems for the high school has in part been fulfilled. The authors recognized a basic need for mathematical treatment of scientific information that is lacking in many high school texts currently available. This statement is not meant as a criticism of the available high school texts; it merely points out that the field of education in chemistry has grown so rapidly recently that it is necessary to do as Sulkoski and Rituper have done. They have introduced the mathematics of chemistry for the high school in a separate volume.

The chapter headings show the areas included. The sub-headings allow a student to find at a glance the place in the book he needs. Each topic is discussed in enough depth for the "average" high school curriculum. The text should serve chemistry classes with review problems that the student should do on his own or have assigned.

In light of the newer trends of chemical curricula through programs such as CHEM and CBA the book has its limitations in that it will become dated. It does not show a good development of the mole concept through gases or electrochemistry. Oxidation-reduction is not developed by the E° values. The writer also feels that the treatment of chemical kinetics could have been somewhat more extensive.

"Basic Chemistry Problems for the High School" can serve the teacher of chemistry in a basic course. The use of dimensions or units for problem solving is an excellent method to give to beginning chemistry students. Adequate treatment has been given to problems involving standard solutions. The use of problems and equations concerning nuclear chemistry gives to the teacher examples he might use should his own knowledge be limited. The reviewer recommends this volume to teachers and students of basic chemistry at the high school level to serve them as they need.

JOSEPH S. SCHMUCKLER
Haverford Township Senior High School
Havertown, Pennsylvania

Advances in Chemical Physics. Volumes 4 and 5

Edited by *I. Prigogine*, University of Brussels, Brussels, Belgium. Interscience Publishers (a division of John Wiley and Sons, Inc.), New York, 1962 and 1963. 400 and 410 pp. 15 × 23 cm. $16.50 each.

Teachers of freshman and undergraduate physical chemistry will find the articles in Volume 4 of this series on the theory of optical activity of small molecules (A. Moscowitz), effects of high pressure on electronic structure of solids (H. G. Drickamer and J. C. Zahner), and the structure and properties of metal-ammonia solutions (T. P. Das) particularly interesting sources of new lecture material. Moscowitz breathes new life into the one electron theory of optical rotation of Condon, Altar and Eyring in addition to presenting a very readable, concise survey of the many contributions made in this field since the late 1920's. The article by Drickamer and Zahner illustrates how spectroscopic data on sample systems such as nickel dimethylglyoxime subjected to pressures of the order of 100 kilobars can be used to classify spectra and reveal the interactions between neighboring atoms and ions in crystals. There is almost too much experimental detail in the article by Das to hold the reader's interest, but his synthesis of conflicting theories of metal-ammonia solutions into a new theory that accounts at least qualitatively for the varied experimental results is intriguing. The remaining articles on random walk (F. H. Ree, T. S. Ree, T. Ree, and H. Eyring), optical activity of polymers (I.T inoco, Jr.), the one-dimensional plasma (S. Prager) and the quantum mechanical distribution function of molecular systems: translational and rotational motions (H. Friedmann) are no less authoritative but probably too specialized to interest most chemists. The contributing authors to both volumes generally fulfill Prigogine's promise of presenting well informed points of view rather than encyclopedic literature surveys.

There are eight articles in Volume 5: the one-electron theory of π-electron systems—particularly the aromatic hydrocarbons (H. Hartmann), a ligand field theory treatment of the spectra of the transition metal complexes, the lanthanides and actinides that is much the longest article in the book (C. K. Jørgensen), a treatment of non-spherical molecules both as real gases and in the crystalline state (T. Kihara), theories on the magnetic properties of the compounds of the 3d group metals (S. Koide and T. Oguchi), a succinct exposition of forbidden electronic transitions (A. D. Liehr), a statistical theory of transport processes (J. A. McLennan, Jr.), a quantum mechanical interpretation of nuclear quadropole coupling data (E. Scrocco), and a bimolecular collision theory of chemical reaction rates in dilute gases (B. Widom). The theoretical slant of all these articles will make them less useful to a teacher of undergraduates than the three articles cited above in Volume 4.

Unlike some other review series, there is no apparent editorial drift from the general to the particular in the contents of the five volumes of "Advances in Chemical Physics." Furthermore, the quality of the contributions is unimpeachable; the ready availability of these volumes in university libraries is clearly desirable. However, one minor objection should be raised. A number of subjects, particularly experimental ones such as high resolution nuclear magnetic resonance, mass spectra and Raman spectra, that frequently grace the pages of the *Journal of Chemical Physics* have been displaced from the pages of "Advances" by too frequent articles on statistical mechanics. A balance in subject matter for "Advances" that more accurately reflects the broad interests of chemical physicists would be welcome.

E. M. EYRING
University of Utah
Salt Lake City

Infrared Absorption Spectroscopy

Koji Nakanishi, Tokyo Kyoiku University. Holden-Day, Inc., San Francisco, 1962. ix + 233 pp. Figs. and tables. 19 × 26 cm. $8.

One of the best justifications for writing a new book is that it fills a definite need. The book, "Infrared Absorption Spectroscopy," by Koji Nakanishi employs the approach of learning by doing in order to familiarize the beginning worker in this field with the techniques. The introductory material gives the frequencies at which different groups absorb. This is similar to the information contained in Bellamy's Book. A very useful chapter deals with the shifts and absorption bands. Such factors as concentration and solvent effects are discussed with the aid of diagrams.

The latter part of the book consists of 85 problems in infrared spectroscopy. A student who conscientiously works through these problems should have a clear idea of important factors in the field. The answers are given in a separate section with detailed discussions supporting the deduction.

It would seem feasible to employ this technique in other areas of chemistry to the advantage of the student. This book should prove useful to the senior undergraduate or first-year graduate student who is interested in obtaining a practical knowledge of infrared spectroscopy.

THEODORE R. WILLIAMS
College of Wooster
Wooster, Ohio

(Continued on page A894)

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NEW AP BOOKS

Introduction to Modern Biochemistry

By P. Karlson
Translated from the German by Charles H. Doering
1963, 434 pp., $10.00

This important textbook provides a completely integrated guide to the established facts, dominant theories, and modern applications of biochemical research. The work synthesizes the vast knowledge gained in recent years in such fields of research as molecular biology, the chemistry of vitamins and hormones, the constitution and mechanism of action of enzymes, metabolism, and the production, conversion and utilization of energy, and relates this knowledge to biological function.

Interfacial Phenomena

Second Edition

By J. T. Davies and E. K. Rideal
October 1963, 493 pp., $15.00

Review of the First Edition:

"The principles of classical surface chemistry are well and concisely set forth, but the real value of the book is in its comprehensive treatment of modern work . . . . The authors are to be congratulated on a first-class book. Few, if any, others could have presented the modern work as fully or skillfully."—*Nature*

The Biosynthesis of Vitamins

and Related Compounds

By T. W. Goodwin
November 1963, 366 pp., $11.00

This monograph correlates for the first time the information currently available on the biosynthesis of vitamins, surveying in detail the important advances which have been made in the last decade and assessing their significance.

The Chemistry and Function of Proteins

Second Edition

By Felix Haurowitz
1963, 455 pp., $10.00

Reviews of the First Edition:

"There is no rival to this book at present and it is fully worthy of the many readers of which it seems to be assured."—*Science Progress*

"The book is to be recommended as an advanced textbook on the subject as well as a handy reference for workers in the field."—*Journal of the American Medical Association*

Non-Stoichiometric Compounds

Edited by L. Mandelcorn
Fall 1963, about 650 pp., approx. $22.50

This book deals in detail with non-stoichiometric compounds which include oxides, sulfides, selenides, etc., and inclusion compounds of inorganic, organic, and solution types. Particular emphasis is placed on the structural features and physical properties of these systems.

The Proteins

Composition, Structure, and Function

Second Edition

Edited by Hans Neurath
Volume 1, Fall 1963, about 675 pp., $20.00

Review of the first edition:

"Considered together, these four volumes will be referred to for many years, not only for all phases of the chemistry of these important macromolecules, but also for their biological properties and biological activities."
—*Journal of Chemical Education*

SERIAL PUBLICATIONS

Advances in Organometallic Chemistry

Edited by F. G. A. Stone and Robert West
Volume 1, Early 1964 about 300 pp.

This series will publish authoritative reviews on recent developments in all aspects of the chemistry of metal-carbon compounds: structural, theoretical, synthetic, and technological. The first volume will include articles on organosilicon polymers, metal acetylene derivatives, diene complexes, and on nuclear magnetic resonance and vibrational spectroscopy of organometallic compounds.

Survey of Progress in Chemistry

Edited by Arthur F. Scott
Volume 1, October, 341 pp., $7.95

The topics covered in the first volume of the series are: new research tools of the chemist, high temperature reactions, new inorganic structures and their implications for valence theory, metallocene chemistry, oxidation-reduction mechanisms in organic chemistry, the chemistry of biological energy transfer, and the structure of the Grignard reagent.

Progress in Nucleic Acid Research

An International Series
Edited by J. N. Davidson and Waldo E. Cohn
Volume 1, 1963, 424 pp., $13.00
Volume 2, December 1963, about 350 pp., approx. $12.50

This serial publication, which reflects the rapid day-to-day progress in the field of nucleic acid research, presents much more than the standard "Review" of recent literature. It provides a medium for the presentation of new theories and techniques, discussions of controversial material, and publication of timely and significant advances in the field.

Progress in Chemical Toxicology

Edited by Abraham Stolmon
Volume 1, October 1963, about 400 pp., $14.00

This new serial publication will report on the usefulness of the newly developed techniques and methods, and evaluate their toxicological significance. Volume 1 emphasizes methodology related to the development and techniques applicable to the fields of forensic and clinical toxicology.

Detailed information available upon request.

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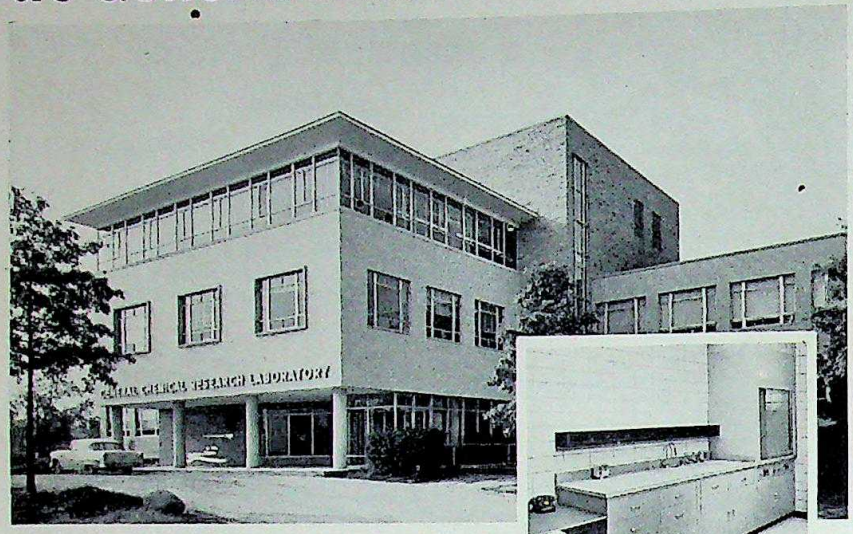

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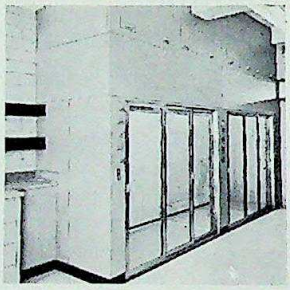
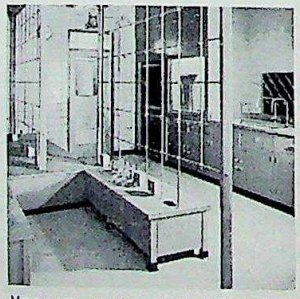
General Chemical Division of Allied Chemical Corp. has established new centralized research facilities in Morristown, New Jersey. The extensive laboratories are equipped with Conflex laboratory furniture throughout. Blickman specialized hoods for handling hazardous materials are also part of the installation. To learn more about versatile Conflex equipment and how well it can serve your laboratory, request literature or ask for a representative to give you engineering assistance.

Counter assembly with fume hood at right. Drawers and cupboards are interchangeable after installation.



Walk-in fume hood. Sliding glass doors have stainless steel frame. Equipped with remote control service valves and switches.



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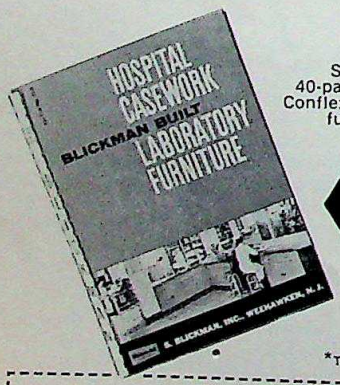

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BOOK REVIEWS

Developments in Inorganic Polymer Chemistry

Edited by *M. F. Lappert* and *G. J. Leigh*, both of the University of Manchester, England. American Elsevier Publishing Co., New York, 1962. xi + 305 pp. Figs. and tables. 14.5 × 22 cm. $10.

Combinations of multivalent elements other than carbon have been studied with unusual intensity during the past ten years, perhaps chiefly because of the need for polymeric materials capable of withstanding temperatures well beyond the useful range of the readily available organic plastics and elastomers. However, most of the promising inorganic chains proved to be too labile or reactive for practical use, and indeed many polymer chains are less stable than small rings made of the same polymer-units. Accordingly, there has been much attention to small-ring compounds, partly because their chemistry was within reach of the usual chemical techniques, but also because the small-ring chemistry had to be well understood before one could hope to stabilize the high-polymer forms.

The present book summarizes a considerable number of these recent developments, without attempting the altogether too large task of covering all types of inorganic polymers in full detail. As a collection of chapters by different specialists, it cannot be expected to maintain uniform quality, and indeed the various authors range from fairly perfunctory to very thorough and scholarly.

In the first chapter, Professor Emeléus very concisely introduces a wide range of types concerning almost exclusively the main-group elements (including some unusual fluorocarbon types); and thereby the novice would gain insight into the kinds of combination which lead to the polymeric condition. Then we find a 33-page chapter by Lappert, reviewing boron-nitrogen polymers and presenting a 5-page bibliography of these interesting near-imitators (with sharp differences) of carbon-chain polymers. The next chapter, by J. M. C. Thompson, extends the analogy farther afield, with mention of boron-hydride polymers, B-B linked oxides, boroxines, copolymers of boron oxide with silicones and other units, boron phosphate types, phosphinoborines, and the very labile sulfur-boron polymers. Then we find a relatively brief but extremely useful survey of the P-N system by an important innovator in that field, N. L. Paddock. Another important contributor, M. Becke-Goehring, tells of her own work in this field, in a chapter covering also her strong interest in the relatively unstable sulfur-nitrogen system.

The famous and almost classical silicone polymer system is modernized in a 22-page chapter by J. S. Hughes, and then J. Idris Jones presents 90 pages on copolymer types involving silicone units with a very considerable variety of units based upon other multivalent elements. However aware we might be, that the possible in-

(*Continued on page A896*)

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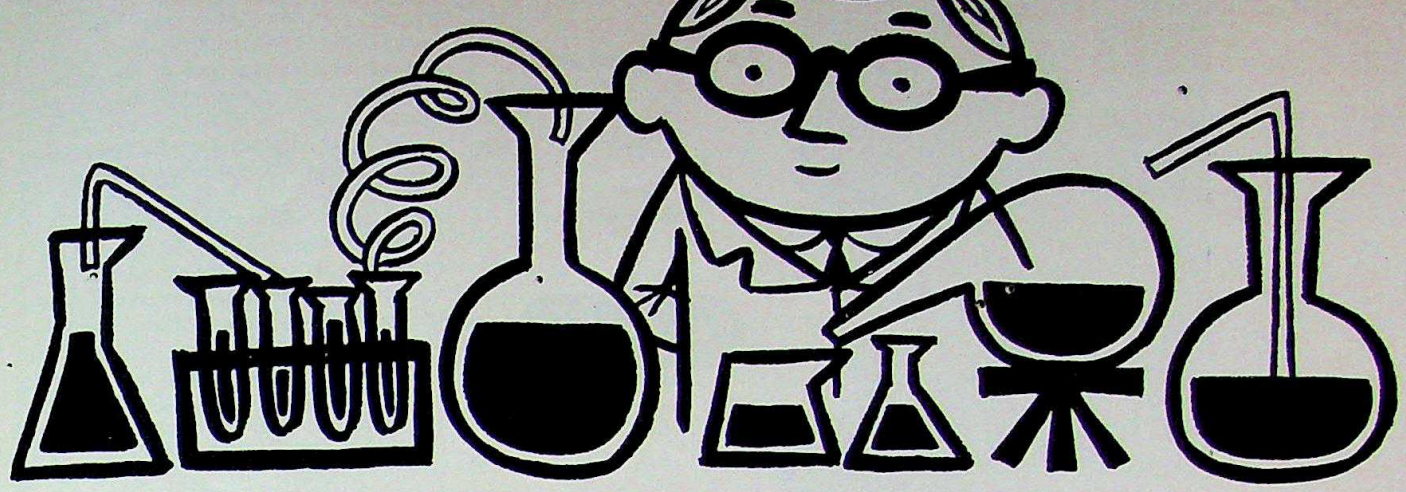

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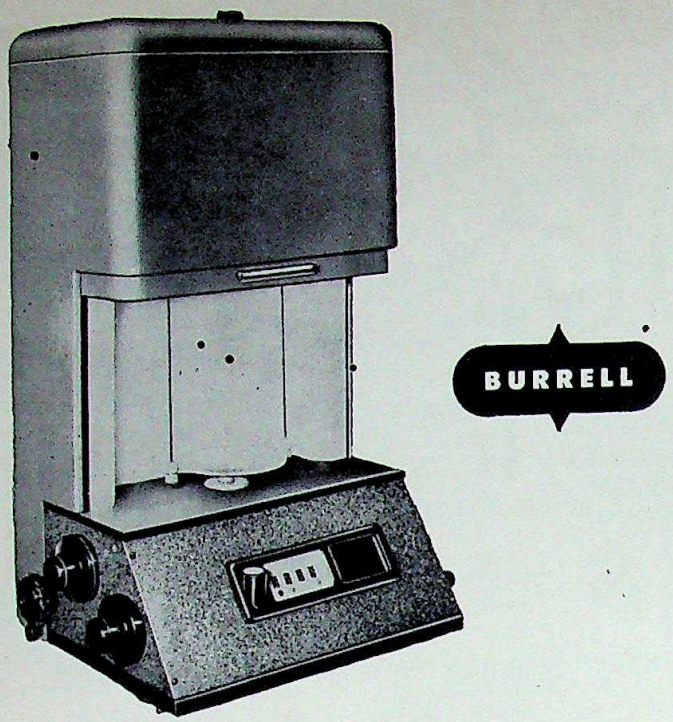

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organic polymer types are enormously many, these two chapters must leave us gasping at the prospect of the unimaginably more numerous copolymer combinations.

The final chapter, by C. N. Kenney, quite briefly discusses some polymer types based upon metal chelation—wherein the chain and ladder-type connections are primarily organic. Again one gains a vista of extreme possible complexity, as the variety of organic patterns combines with the versatility of coordination chemistry.

On the whole, this book serves to open minds to wide areas of chemistry not often met in university courses, and demonstrates how important it is for students to develop a very sound background in inorganic chemistry even though they may intend to pursue other specialties. The main intent of the book is more descriptive than theoretical, but the authors are people having intimate experience with their subjects, and their basis for understanding quite frequently enters the discussion.

ANTON B. BURG
University of Southern California
Los Angeles

Introduction to Polymer Chemistry

John K. Stille, University of Iowa, Iowa City. John Wiley and Sons, Inc., New York, 1962. xi + 248 pp. Figs. and tables. 15.5 × 23.5 cm. $6.95.

This book is designed as an introductory text in polymer chemistry. Numerous subtopics are included under each major topic, and the table of contents includes these subtopics with page numbers for convenience of the casual reader, or for use of the book as a ready reference.

While the physical chemistry and characterization of polymers are discussed briefly, this book treats polymer chemistry predominantly from the organic chemist's viewpoint. Numerous references are cited for adequate sources of rigorous treatment of the various physical aspects of polymer chemistry, however.

The teacher of organic or physical chemistry who would like to give his students a more thorough background in the organic reactions which are capable of leading to high polymers as well as the physical aspects of polymers could well use this book as a supplementary textbook. In addition, practicing chemists or chemical engineers beginning a synthetic program in polymer chemistry would find the information supplied by the author on the various polymerization reactions as well as the reference material quite useful. Use of this book as a text for a beginning course in polymer chemistry, either at the advanced undergraduate level or at the graduate level, provided the lecturer supplements the material from the various specialized sources or from the current literature, is certainly appropriate. The excellent treatment of classical and mod-

(*Continued on page A898*)

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BOOK REVIEWS

ern approaches to polymerization reactions, and the nature, structure and chemistry of initiators in vinyl polymerization, make the book particularly adaptable to use in organic chemistry courses. Among the topics of recent interest discussed under the conventional condensation polymer systems are the polyimides, polyimidazoles, and polytriazoles, structures which possess high thermal stability.

The separate discussion of polymerization by ring-opening reactions is a particularly novel approach to these systems. While, in general, these reactions can be considered as a special class of addition polymerizations, they are more easily understood by the novice in the field when summarized as the author has done, and treated as a class. A special class of polymerization reactions are discussed separately, predominantly because they do not lend themselves to easy classification among the well-known broad classes.

The various types of vinyl addition polymers are discussed mainly from a structural standpoint although the preferred initiator systems for each type are included. Also, as supplementary information for the reader of this chapter, information on the various types of initiator systems is presented in the discussion of mechanisms and kinetics of polymerization.

The brief treatment of naturally occurring polymers includes some excellent illustrative material. In general, the format and illustrations are excellent, and the reader is given some insight into the three-dimensional nature of polymer systems which is not readily apparent from many other sources of information. An excellent treatment of stereoregularity in polymers is also included.

George B. Butler
University of Florida
Gainesville

An Introduction to Polymer Chemistry

W. R. Moore, Bradford Institute of Technology, England. University of London Press, Ltd. (published in U.S.A. by Aldine Publishing Co., Chicago), 1963. 270 pp. Figs. and tables. 14.5 × 22.5 cm. $7.50.

In the preface, the author makes the following statement: "There are many textbooks and monographs, often rather expensive, which deal at an advanced level with the physical and organic chemistry of high polymers and with specialized aspects in these fields. Reasonably compact and moderately priced books providing an introduction to the rapidly expanding field of high-polymer chemistry are less common. This text, based on lectures given by the author and his colleagues at post-graduate and undergraduate levels. . . is an attempt to provide such a book." A rather careful examination of the contents leads to the conclusion that the author has accomplished his purpose very well. The topics discussed, following a brief introductory chapter are the following: poly-

(*Continued on page A900*)

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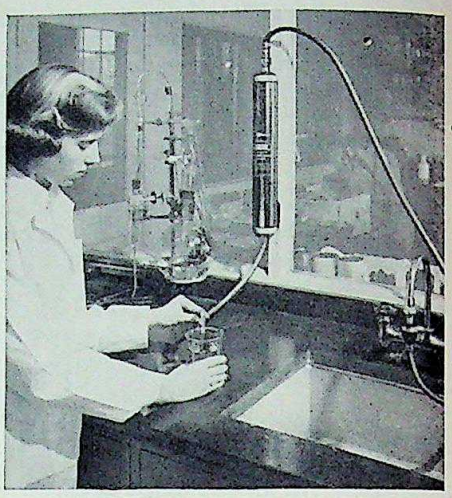

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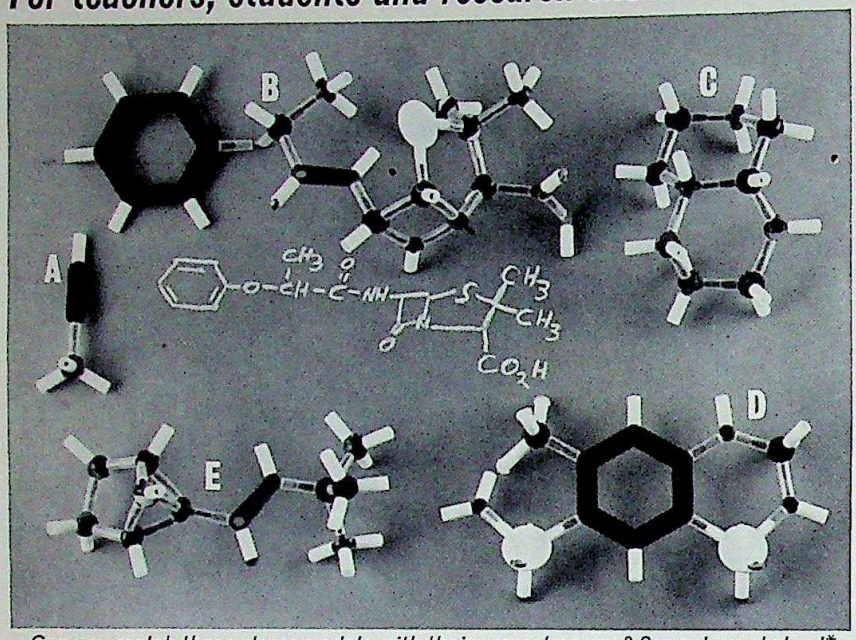

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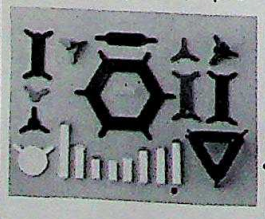

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merization, the structure and properties of polymers, the interaction of polymers and liquids, synthetic organic addition polymers, synthetic organic condensation polymers, inorganic and semi-inorganic polymers and natural organic high-polymers.

Each of the topics discussed, if treated exhaustively, would occupy several volumes, and such volumes are available; however, the discussion included here is adequate for the beginner in polymer chemistry, either as a student of chemistry or chemical engineering at the undergraduate level or as a research chemist in the laboratory beginning a program of synthetic polymer chemistry or a study of polymer properties. Numerous references are included to introduce the reader to these valuable treatises on the various subjects. The biochemist interested in becoming more familiar with the chemistry of the synthetic counterparts of the naturally occurring high polymers which he deals with largely will find this book of considerable value.

The teacher of organic or physical chemistry at either the graduate or undergraduate level would find this book quite useful as a supplementary text for introducing the subject of high polymer chemistry to his students. As a text for a course in high polymer chemistry at either the advanced undergraduate or graduate level this book would be ideal, provided appropriate supplemental material either from the wealth of specialized topics sources or from the current literature were used.

The format and illustrations are pleasing to the reader, and topic headings within each chapter are set apart for easy location by the casual or rapid reader.

The various methods of determination of molecular weights and other physical properties of polymers are discussed briefly and the fundamental theories presented. Little detail as to the experimental procedures necessary for carrying out these operations in the laboratory is given, but reference material is cited. The tremendous importance of stereoregularity in polymers is perhaps not sufficiently emphasized in the book, although a discussion is presented. Numerous interesting and potentially important polymer systems are omitted. For example, the "1-nylons" derived from anionic polymerization of organic isocyanates are not discussed; however, such recent copolymers as the tetrafluoroethylene-trifluoronitrosomethane copolymers are briefly referred to.

GEORGE B. BUTLER
University of Florida
Gainesville

Essentials of Biological Chemistry

James L. Fairley and *Gordon L. Kilgour*, Michigan State University, East Lansing. Reinhold Publishing Corp., New York, 1963. xiii + 287 pp. Figs. and tables. 15.5 × 23.5 cm. $7.50.

The authors have undertaken to write a text for an introductory course in bio-

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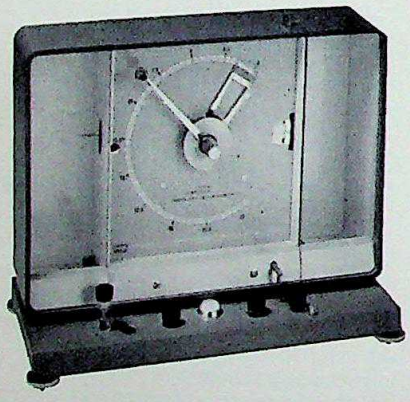

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The brief discussion of enzymes, essentially descriptive, while simplified, is quite good. They state, correctly, "the naming of enzymes has not yet become standardized" without, however, reference to the recommendations presented in the recent Report of the Commission on Enzymes of the International Union of Biochemistry. Since, " in many succeeding reactions the names of the enzymes will be ommitted for simplicity," a fuller presentation of the naming of the enzymes would be valuable.

The authors present briefly, but clearly, with formulas, equations and diagrams, the essentials of the intermediary metabolism of the carbohydrates, lipids, proteins, and amino acids, and the biosynthesis of these substances, and of the purines, pyrimidines, and urea. They have made a successful endeavor to bring the material up-to-date. The student is given briefly a basic acquaintance with a great variety of related and pertinent topics.

The authors recurrently emphasize inter-relationships in the processes of metabolism and the coordinated control of these. They bring out explicitly interpretations that are not commonly presented except by implication. The book bears evidence that it is the product of interaction between students and teachers. With each chapter there is a well-selected

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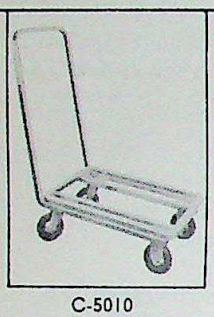
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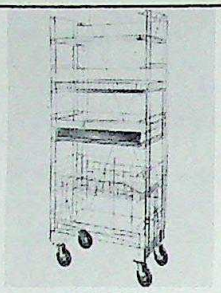
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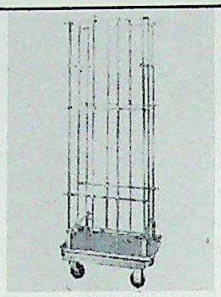
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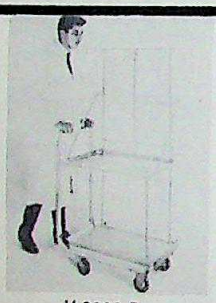
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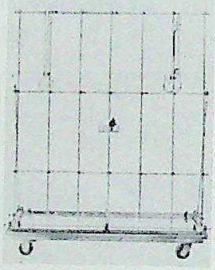
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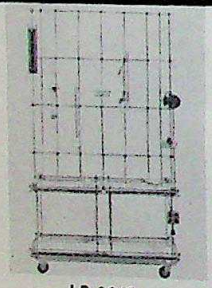
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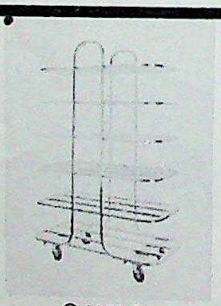
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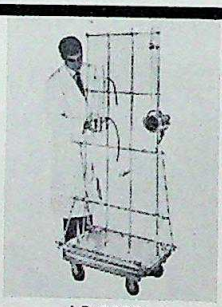
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brief list of references for "suggested additional reading."

This book may be commended warmly to the attention of those teaching biochemistry as a terminal course for those undergraduate students, not highly trained in chemistry, who would otherwise fail to encounter biochemistry as a separate discipline.

RALPH C. CORLEY
Purdue University
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On Divers Arts: the Treatise of Theophilus

Translated by *John G. Hawthorne*, University of Chicago, and *Cyril Stanley Smith*, Massachusetts Institute of Technology. University of Chicago Press, Chicago, 1963. xxxv + 216 pp. Figs. and tables. 17.5 × 25 cm. $8.50.

The increased interest in the history of technology during the last few years is continuing to be a stimulus for the publication of scholarly translations into English of important technological texts written in medieval Latin, old Italian, old German, and other difficult languages. The present volume is a welcome addition to the small group of English translations of treatises which deal more or less with chemical technology. The present work also is of special interest since it marks the cooperative effort of the well-known metallurgist and historian, Cyril Smith, with a well-known classicist.

Theophilus is thought to be the pseudonym of a German metalworker and Benedictine monk, Roger of Helmarshausen. Theophilus' treatise written in medieval Latin is particularly important for the history of chemical technology, since it has been well established that the writer of the treatise was a practical worker in the arts which he describes and not just a compiler of recipes as was common with most authors of medieval treatises on technology.

Theophilus was not a scientist in our modern sense but a technologist skilled in the best techniques concerned with the manufacture, preparation and mixing of pigments for painting, the making of glass and in special methods of metal working. The translators of this work point out that while Theophilus' treatise has been well known to art historians because of the detailed discussion of paint making, they have also emphasized in detail the instruments and techniques used for glass making and metal working. The translators have reconstructed many of the instruments and apparatus described by Theophilus and have illustrated these and their method of operations by drawings. Detailed bibliographical information on the various texts and translations of Theophilus' treatise are presented and a number of fine illustrations in addition to the drawings of the reconstructed instruments and apparatus

(*Continued on page A906*)

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are also included. Many technical notes by the translator make clear certain obscure passages.

It is to be noted that another English translation of Theophilus' treatise was published in 1961 under the authorship of C. R. Dodwell, and Dr. Smith and Dr. Hawthorne have exchanged a great deal of information with Dodwell.

This book is recommended to students of the history of technology of chemical arts, to art historians, and, of course, to bibliophiles and book collectors concerned with the history of technology.

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Progress in Drug Research. Volume 4

Edited by *Ernst Jucker*, Basel. Interscience Publishers (a division of John Wiley and Sons, Inc.), New York, 1962. 606 pp. Figs. and tables. 17.5 × 24.5 cm. $30.

Contributors: Von H. Herbst; N. J. Harper; E. Schlittler, J. Druey, and A. Marxer; Von H. Grasshof; J. C. Arcos and M. Arcos.

Pentose Metabolism in Bacteria

B. L. Horecker, New York University School of Medicine, New York. John Wiley and Sons, Inc., New York 1962. vii + 100 pp. Figs. and tables. 13 × 19 cm. $4.

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Nouveau Traité de Chimie Minérale. Volume 20, Alliages Métalliques, Part 2

Paul Pascal, general editor. Masson et Cie., Paris, 1963. L + 1153 pp. Figs. and tables. 17.5 × 26 cm Broché, 200 NF; cartonné toile, 212 NF.

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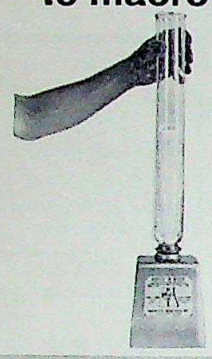

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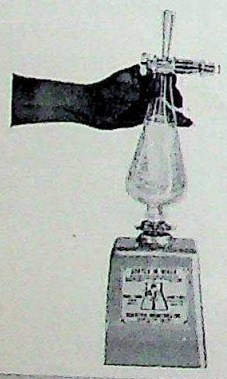

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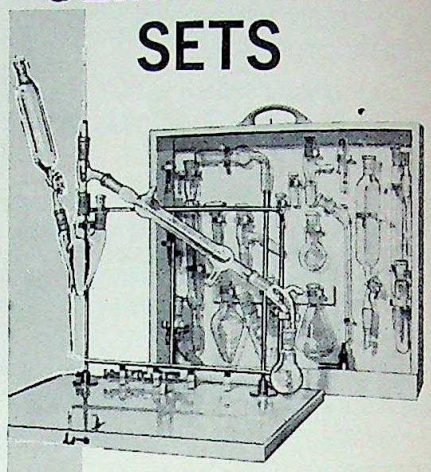

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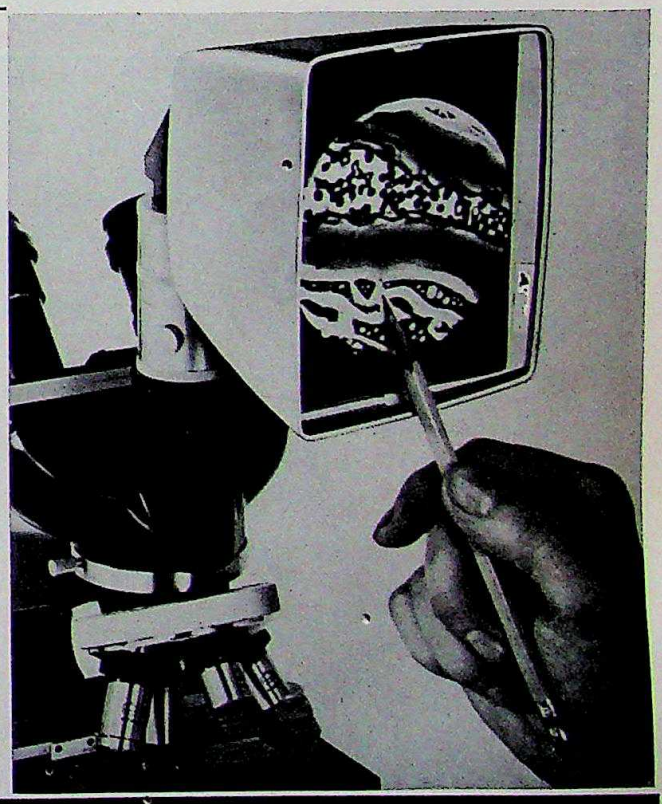

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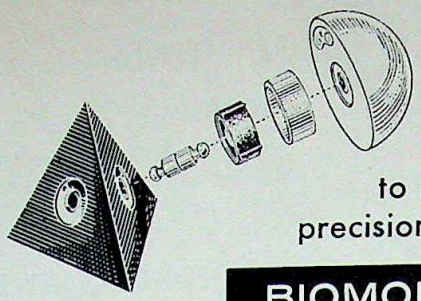

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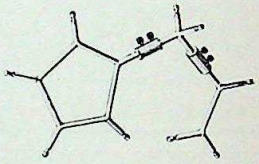

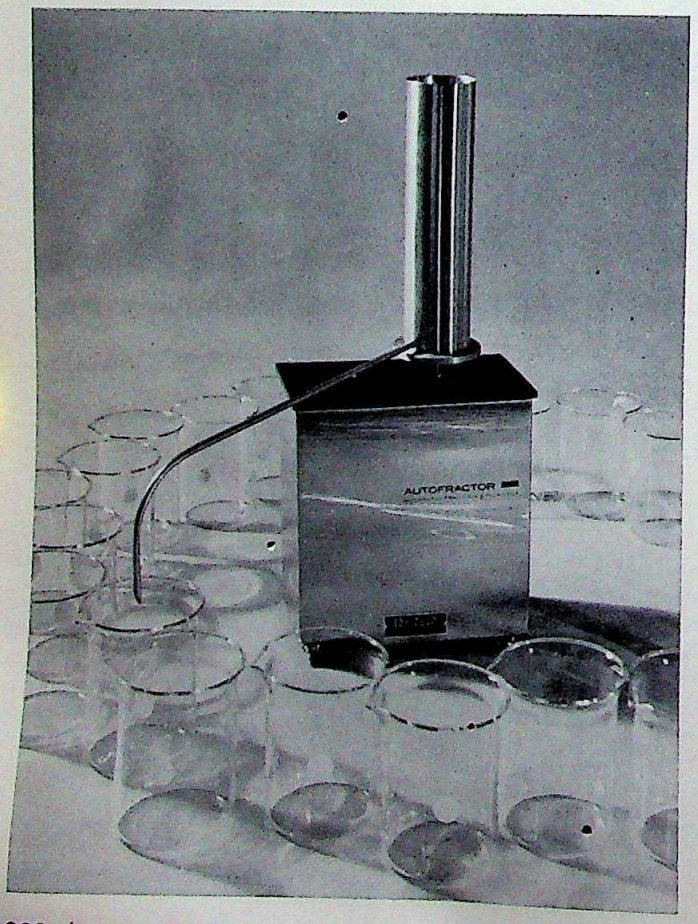

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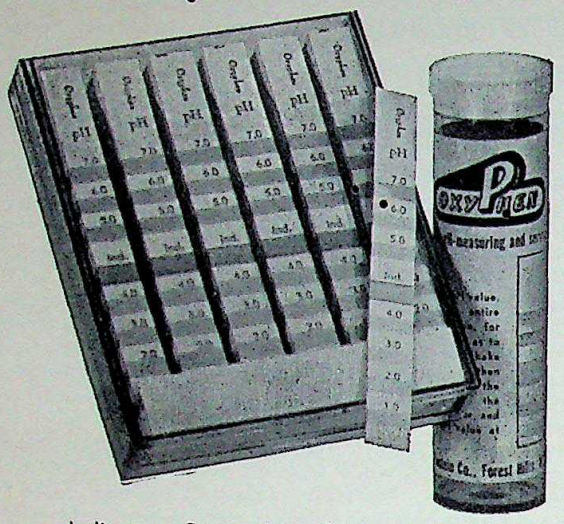

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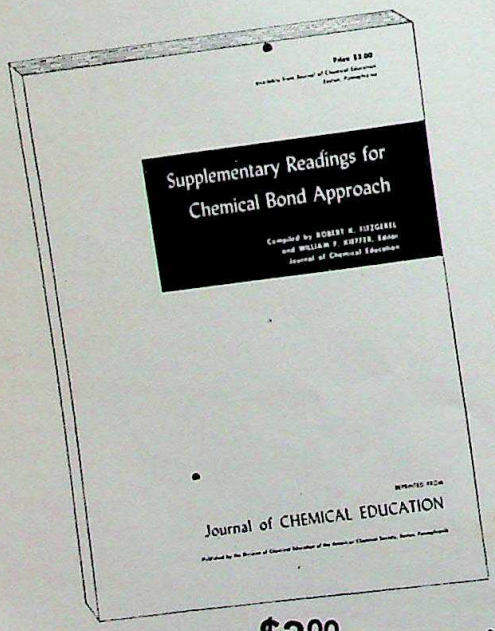

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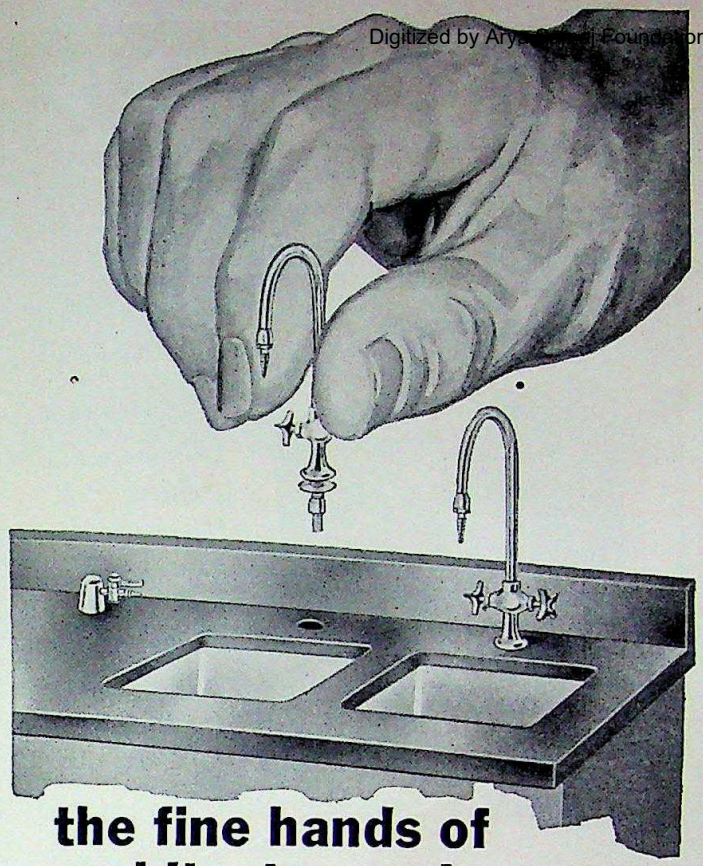

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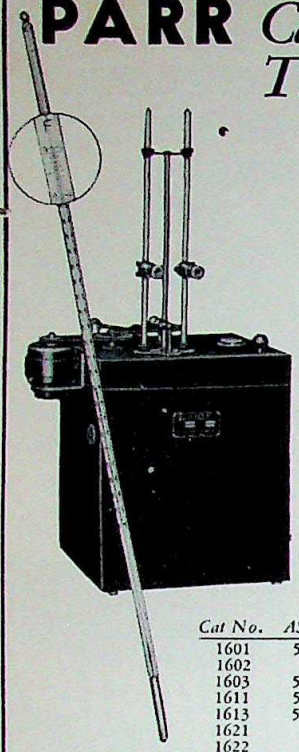

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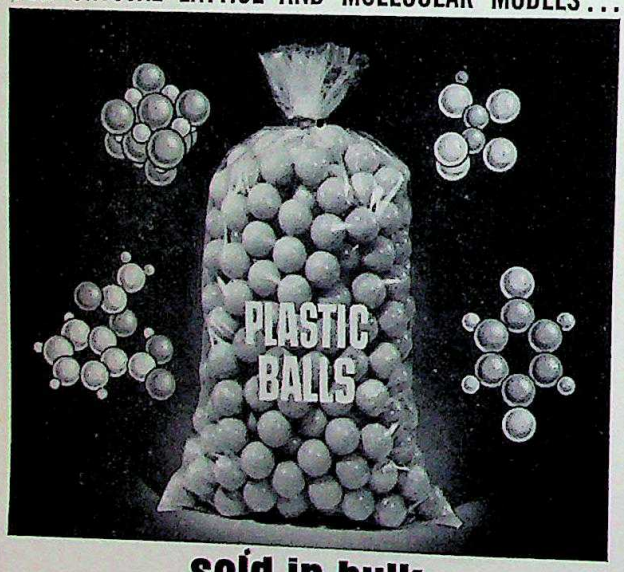

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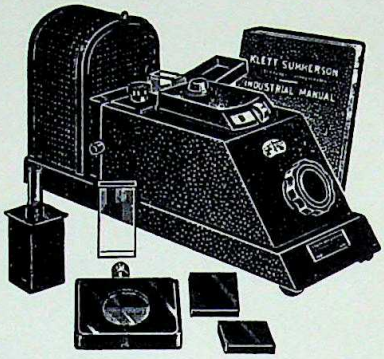

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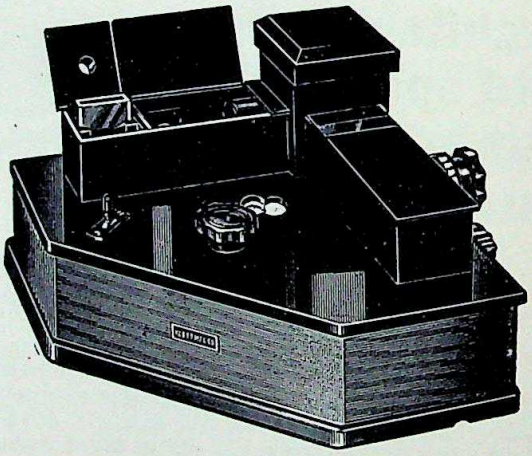

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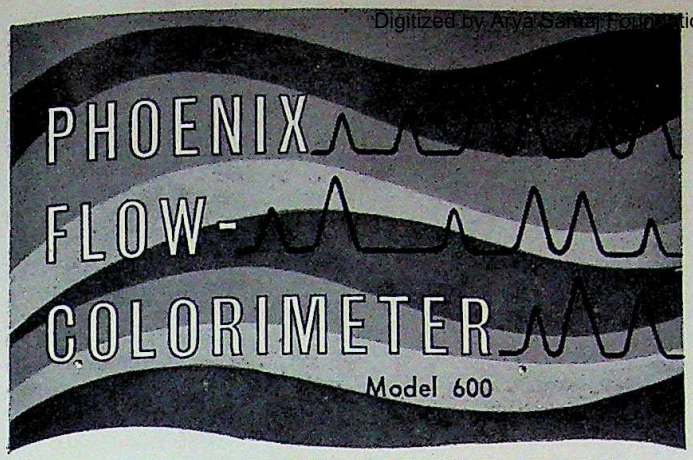

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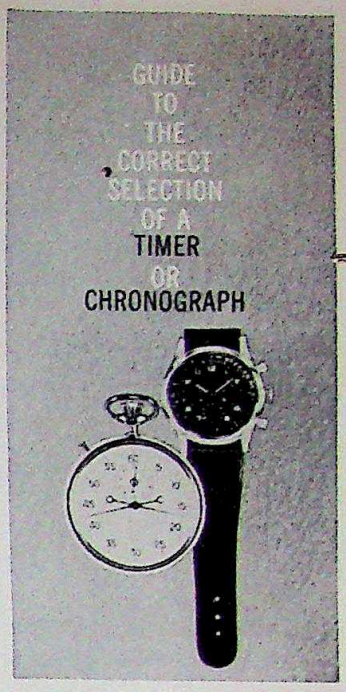

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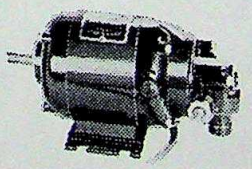

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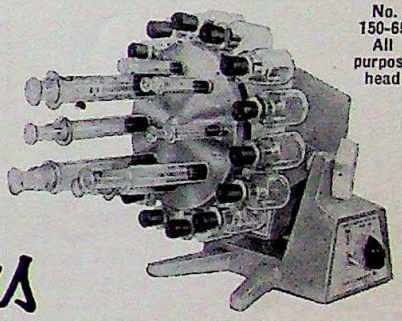
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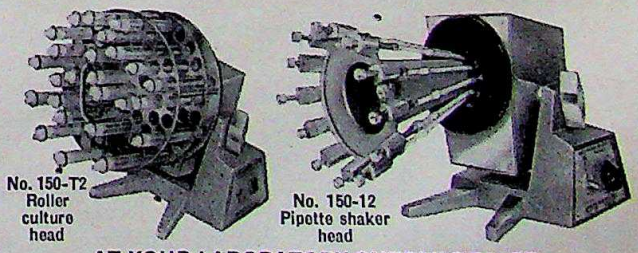
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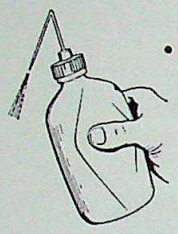

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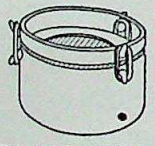

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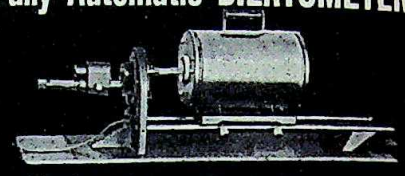

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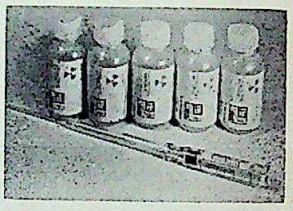

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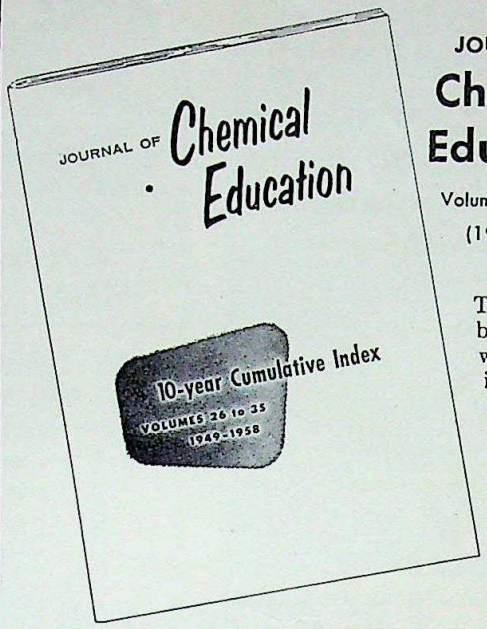

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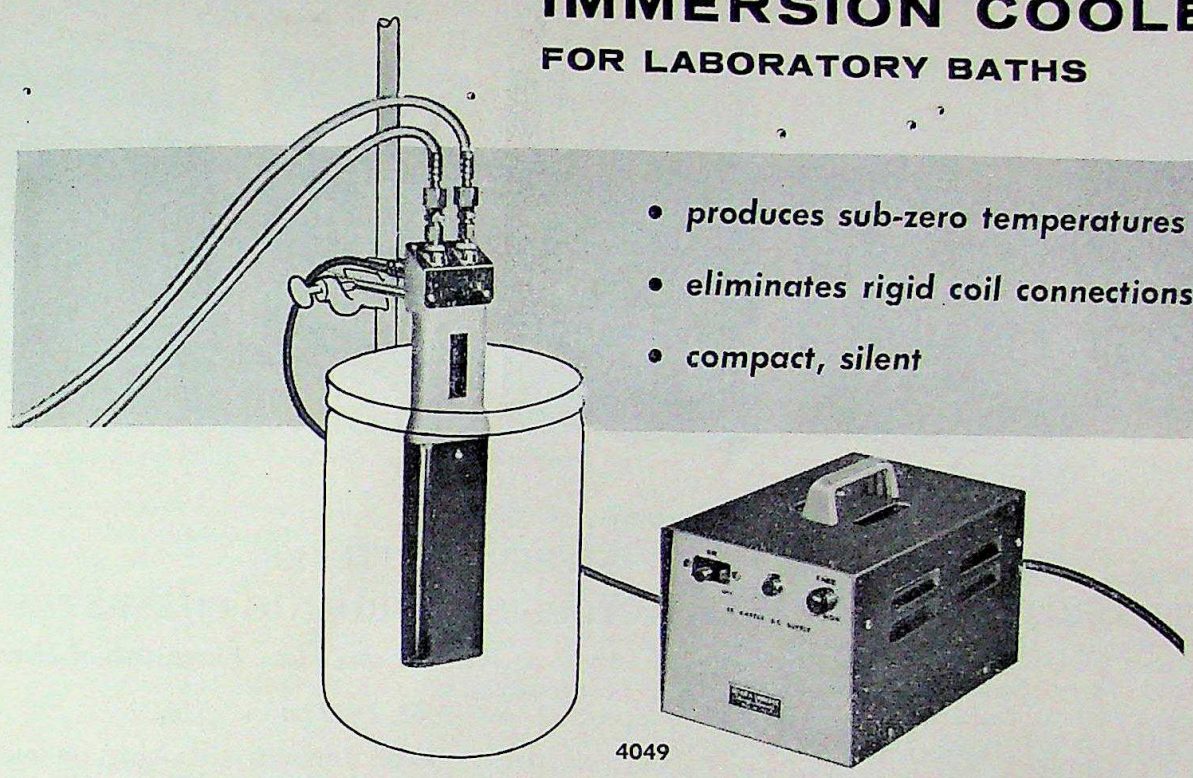

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Cooling Unit. Made in the form of a thick nickel-plated copper blade, the cooling surface is 6 inches long × 2¾ wide × 1⅛ inches thick, providing an effective area of approximately 45 square inches when immersed to recommended depth. Three-pin receptacle for power input and tapped hole for horizontal attachment of 5½ × ⅜-inch diameter mounting rod are provided in polypropylene shank. Two ¼-inch o.d. tubulations emerge from top for connection of tubing for cooling water input and discharge. Thermoelectric modules within the outer shell are bonded to a cast bronze heat sink which is cooled by the passage of tap water. A thermal cut-off switch attached to the heat sink closes at 71°C if cooling water is inadvertently shut off *(see Power Supply)*.

Power Supply. Suitable for unattended, continuous operation to provide 3-volt, 25-ampere d.c. operating power. Contains transformer, two silicon diode rectifiers, choke for reducing output ripple, fuse, pilot lamp and thermal cut-off power switch. Heater in thermal cut-off switch is activated by closure of a bimetal switch attached to the heat sink inside the cooling unit. Although bimetal switch in cooling unit reopens when heat sink temperature drops to 55°C, power will not be restored until power supply switch is reset manually. Plug on d.c. power cable connects the power supply to cooling unit. A.c. input is supplied through a 3-wire cord, with 3-prong plug and adapter.

Cooling Rate. Non-linear; depends upon bath volume and temperature of heat sink coolant. In test with 3.5 liters of ethylene glycol, with coolant and initial bath temperature of 24°C, hourly temperatures were recorded as follows: 14, 4, −3, −8, −12, −14, −16, −17, −18, −19, −20, −21, −22, −23, −24 degrees Centigrade.

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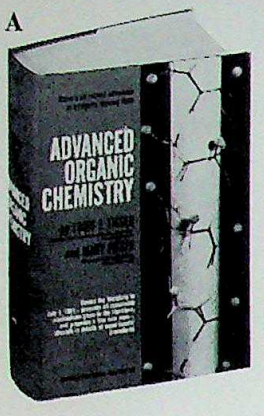

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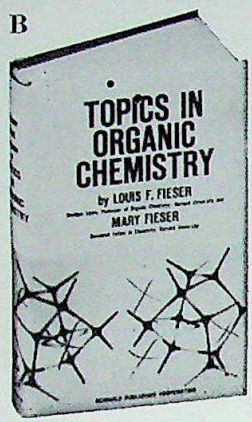

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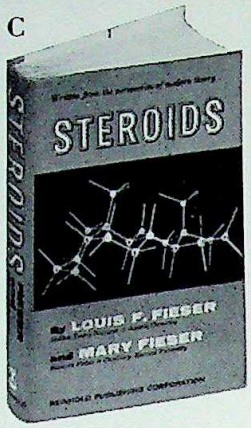

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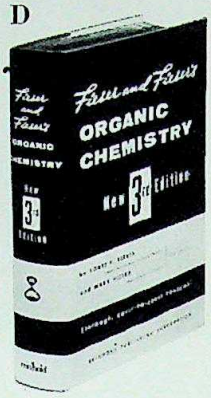

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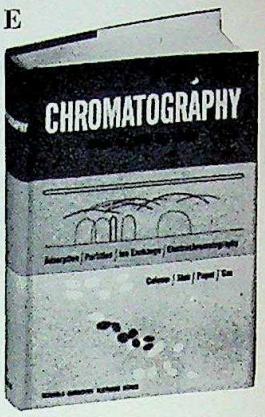

A.

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Topics in . . .

Chemical Instrumentation

. . . a Chem Ed feature

Edited by **S. Z. LEWIN**, New York University, New York 3, N. Y.

These articles, most of which are to be contributed by guest authors, are intended to serve the readers of this JOURNAL *by calling attention to new developments in the theory, design, or availability of chemical laboratory instrumentation, or by presenting useful insights and explanations of topics that are of practical importance to those who use, or teach the use of, modern instrumentation and instrumental techniques.*

X. Emission Spectroscopy. Part One

Stephen E. Wiberley *and* **Herbert H. Richtol**, *Department of Chemistry Rensselaer Polytechnic Institute, Troy, New York*

S. E. Wiberley is Associate Dean of the Graduate School at R.P.I. He was educated at Williams College (B.A. 1941) and R.P.I. (M.S. 1948; Ph.D. 1950). He teaches analytical chemistry and is author of three textbooks and approximately 50 papers in such research areas as spectroscopy and instrumental analysis.

Herbert H. Richtol is Assistant Professor of Analytical Chemistry at R.P.I. He was educated at St. Lawrence University (B.S. 1954), and New York University (Ph.D. 1961). He teaches analytical chemistry and has research interests in the fields of spectroscopy, luminescence and energy transfer processes.

The field of emission spectroscopy is a very broad one and for adequate coverage would require an excessively long article. This review will attempt to emphasize a few of the highlights and recent developments in this field. Flame photometry will not be included since a previous article in this series dealt exclusively with this subject.

General Principles

Emission spectra can arise from excited atoms or molecules with atoms yielding line spectra and molecules band spectra on the photographic plate. Under high resolution the band spectrum of a simple molecule consists of many fine lines closely grouped together so the differences between some band spectra and line spectra are not as pronounced as a casual inspection of the photographic plate would first indicate. The instrumentation for emission spectroscopy will be discussed in terms of line or atomic spectra because the major use lies in this area rather than in the area of band spectra. However, the same instrumentation can also produce excellent band spectra as well.

An electron in the ground state may be excited to a higher energy level if suitable energy can be imparted to the electron by a flame, arc or spark. On returing from this higher energy level to a lower level, radiation is emitted with a characteristic wavelength such that $\Delta E = hc/\lambda$ where ΔE is the energy in ergs, h is Planck's constant, approximately 6.6×10^{-27} erg-sec, c is the speed of light, approximately 3×10^{-10} cm/sec, and λ is the wavelength in centimeters. In emission spectroscopy the wavelengths are reported in angstrom units with the angstrom being originally defined as 10^{-10} m in terms of the standard meter bar. Because the meter bar was not an adequate standard for wavelength measurements, the angstrom was redefined as a unit of length equal to 1/6438.4696 of the wavelength of the red line of cadmium. This value was almost but not exactly 10^{-10} m. Most recently (*1*) the meter has been defined as 1,650,763.73 wavelengths (in vacuum) of the orange-red line of Kr^{86}. With this new definition the angstrom is again exactly 10^{-10} m or 10^{-8} cm.

Since only certain discrete energy transitions are allowed, the radiation is quantized and the wavelengths of the emitted radiation are characteristic of the atom producing the radiation. By measuring these wavelengths or by comparison with spectra of known elements the atom or element can be identified *qualitatively*. The intensity of a given emission line of an element is a function of the probability of the electronic transition taking place and the number of atoms of the element concerned. By measuring the line intensity either photographically or with a phomultiplier tube, *quantitative* analysis can be carried out.

Period \ Group	I	II	III	IV	V	VI	VII		VIII	
1										
2	Li	Be	B	C						
3	Na	Mg	Al	Si	P					
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni
	Cu	Zn	Ga	Ge	As	Se				
5	Rb	Sr	Y	Zr	Nb	Mo		Ru	Rh	Pd
	Ag	Cd	In	Sn	Sb	Te				
6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt
	Au	Hg	Tl	Pb	Bi					
7		Ra		Th		U				

Rare Earths	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

Figure 1. Elements readily detectable spectrographically.

(*Continued on page A928*)

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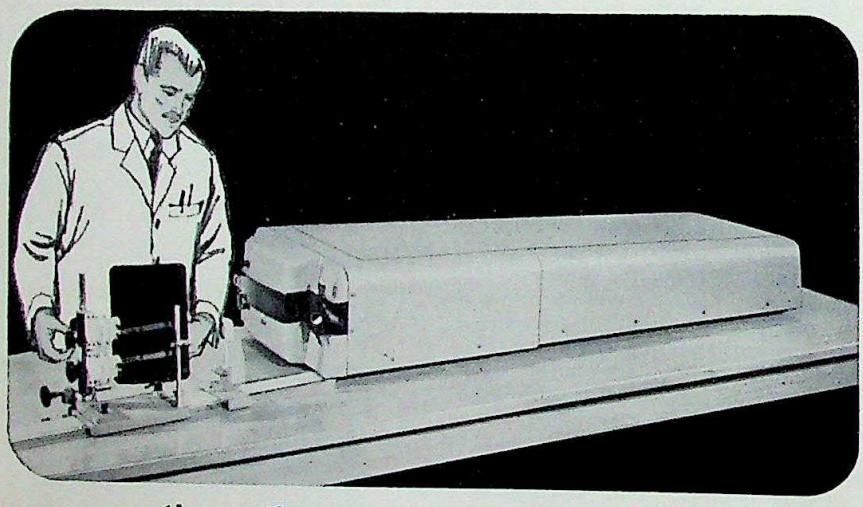
"Wet Method" analyses take five-and-a-half times longer...



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Detection of the Elements

Of the total of over 100 elements which have been discovered, including those made artificially in trace amounts, some 87 have been investigated spectrographically. However, only 72 elements can be readily detected and these elements are shown in Figure 1. De Gramont studied the emission lines that persisted as the concentration of the element was decreased. In 1920 he published (*2*) a table of persistent lines also known as sensitive or principle lines (raies ultimes or letzten linien). In this table he indicated the raies sensibles and raies ultimes as the persistent lines in the visible and ultraviolet regions of the spectrum, respectively. The term raies ultimes was later applied by Meggers (*3*) to include both spectral regions and is used in this sense by spectrographers today.

Using a DC open arc as a source of excitation and a selected RU line in the range of 2000–4600 Å elements detectable in the <1–10 ppm limit include Ag, Al, Au, B, Ba, Be, Bi, Ca, Cr, Cu, Fe, Ga, Ge, In, Mg, Mn, Nb, Pd, Pt, Rh, Si, Ti, and all of the rare earths except Nd, Pr, Sm, and Tb. Elements detectable in > 10–100 ppm limit include As, Cd, Co, Ga, Ni, Pb, Sb, Sn, Sr, Tl, V, Zn, and Zr and > 100–1000 limit include Hg, Se, Te, Th, and U (*4*). With the Stallwood Jet, which controls the direct current arc by surrounding a small diameter electrode vertically with a stream of a mixture of 70 parts argon to 30 parts oxygen, the sensitivity is improved by a factor of 2 or more for most elements. In addition, quantitative accuracy is improved (*5*).

Although not shown in Figure 1 such nonmetallic elements as C, S, Se, P, F, Cl, Br, and I and the gaseous elements such as H_2, O_2, and N_2 can be determined spectrographically. The characteristic spectral lines of the non-metallic elements have excitation potentials two to four times greater than those of the metallic elements with the principal lines being below 2000 Å so either a vacuum or an inert atmosphere must be used in the spectrographic arrangement. Fluorine, chlorine, and bromine combined with an alkaline earth can be analyzed with a DC arc by measurement of the molecular bandhead. For example, calcium fluoride has a strong bandhead at 5291 Å enabling measurement of fluorine in the 50 ppm range. Carbon can be analyzed from bandheads at 3590, 3883, and 4216 Å of cyanogen formed from the combination of nitrogen in the air with carbon in the arc.

In the study of detection limits the purity of the electrodes is an important factor. High purity graphite electrodes are sold with an analysis report containing an estimation of the impurities present. Until recently most graphite electrodes contained boron and vanadium as impurities as well as aluminum, copper, silicon, iron, and magnesium. Selected graphite can be obtained free of one or more of these elements today and is available in a wide variety of preformed electrode shapes from several manufacturers.

(*Continued on page A930*)

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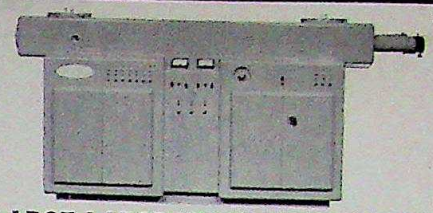
FROM TO

1

TINY SPECTROMETERS

FIXED POSITION
RANGE 1,900A – 10,000A



2

LARGE LABORATORY INSTRUMENTS

3 METER HIGH RESOLUTION SCANNING MONOCHROMATOR CZERNY-TURNER
RANGE 1,000A – 6,000A*

0 — 10,000A

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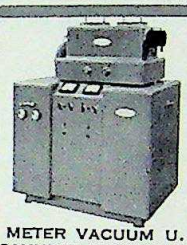
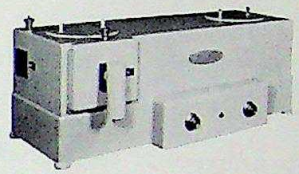


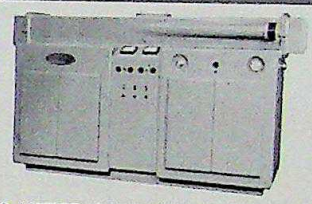
3

.5 METER VACUUM U. V. SCANNING MONOCHROMATOR CZERNY-TURNER
RANGE 1,000A – 6,500A*



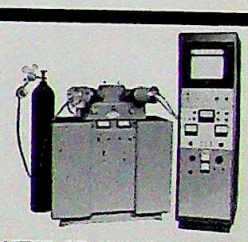
4

1 METER SCANNING MONOCHROMATOR CZERNY-TURNER
RANGE 2,000A – 10,000A*



5

2 METER COMBINATION SPECTROGRAPH AND SCANNING MONOCHROMATOR, EAGLE
RANGE 300A – 6,800A*

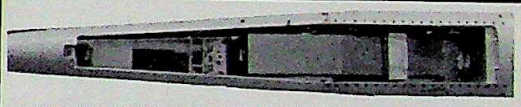


6

.5 METER SCANNING MONOCHROMATOR SEYA-NAMIOKA
RANGE 300A – 6,000A*

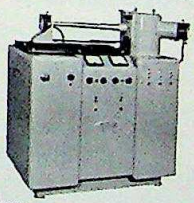
These instruments represent a partial list of the standard spectrometers manufactured by McPherson.

**The range and resolution of these instruments may be increased by interchanging gratings.*



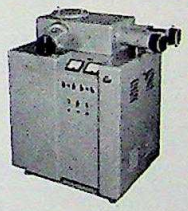
7

NORMAL INCIDENCE ROCKET SPECTROGRAPH FIXED POSITION, RANGE 300A – 3,000A*



8

2 METER GRAZING INCIDENCE VACUUM U. V. SCANNING MONOCHROMATOR, ROWLAND CIRCLE
RANGE 50A – 2,000A*



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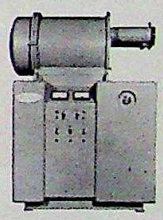
1 METER SCANNING MONOCHROMATOR SEYA AND NORMAL INCIDENCE
RANGE 300A – 6,000A*



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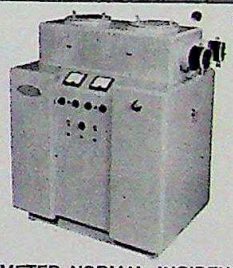

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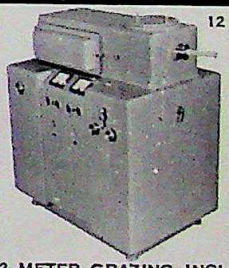
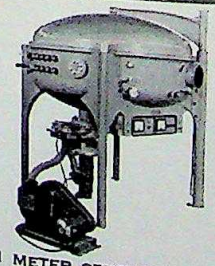
1 METER NORMAL INCIDENCE SCANNING MONOCHROMATOR McPHERSON TYPE
RANGE 300A – 6,000A*



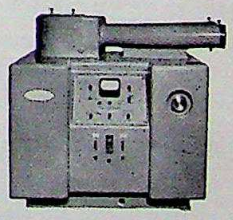
12

2 METER GRAZING INCIDENCE VACUUM U. V. SPECTROGRAPH, FIXED POSITION
RANGE 50A – 2,000A*



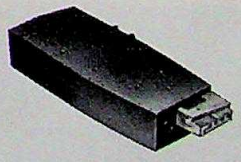
13

1 METER SPECTROGRAPH FIXED POSITION
RANGE 500A – 4,000A*



14

1 METER SCANNING MONOCHROMATOR SEYA-NAMIOKA
RANGE 300A – 6,000A*



15

GRAZING INCIDENCE ROCKET SPECTROGRAPH
RANGE 50A – 2,000A*

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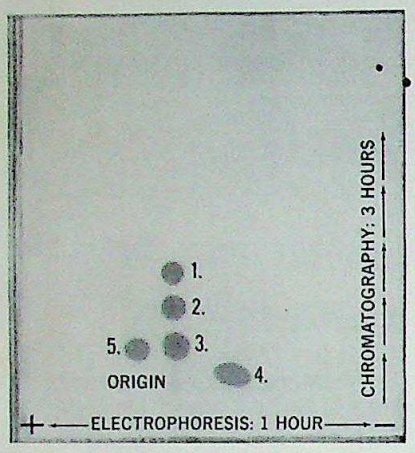
THIN-LAYER ELECTROPHORESIS



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Chemical Instrumentation

Qualitative analysis on a given sample is often carried out by obtaining on the same film the spectrum of the unknown sample and a spectrum of a standard powder containing a large number of elements. Often an iron arc spectrum is also included on the film as an additional reference. Two standard powders available commercially are RU powder and Qual Mix Ru powder consists of a base mixture of calcium oxide, magnesium oxide and zinc oxide to which 47 other elements have been added in such amounts that only a few of the persistent lines appear for each element. Qual Mix is a similar powder containing 43 of the common elements. In many laboratories a standard film, with an iron arc spectrum of half-length lines and the most persistent lines of the elements in full length marked with the element symbol and the wavelength, is kept in a simple comparator or a comparator-densitometer. The film containing the spectrum of the unknown sample is then placed in the comparator and aligned so that the iron arc lines match those of the standard film. The elements in the unknown sample can then be readily identified by comparison with the standard film. Standard films are commercially available for most photographic instruments or can be made to order. A short segment of such a film is shown in Figure 2.

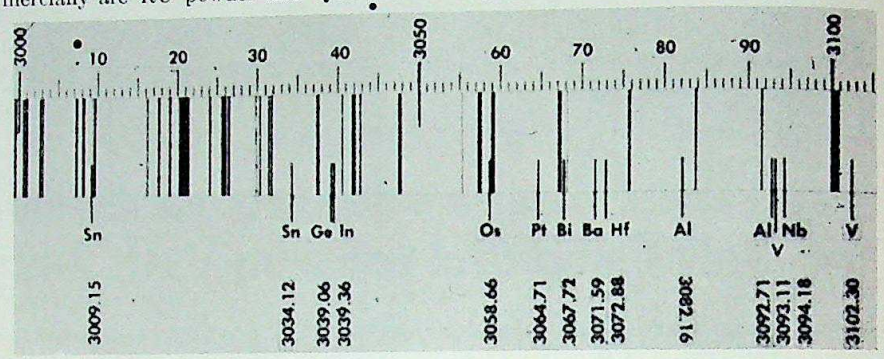

Figure 2. Representative segment of standard comparator film.

Quantitative Analysis

In emission spectroscopy quantitative analysis is usually carried out either for semiquantitative results or for quantitative results with as high a precision and accuracy as possible. In both instances one of the main obstacles to be overcome involves matrix effects. The intensity of

(*Continued on page A933*)

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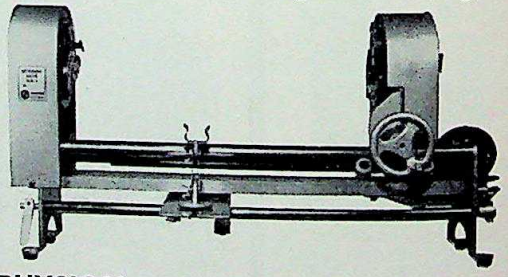

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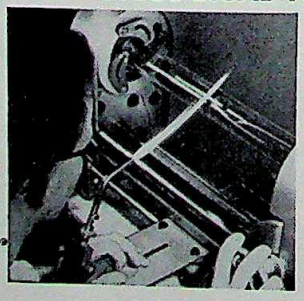

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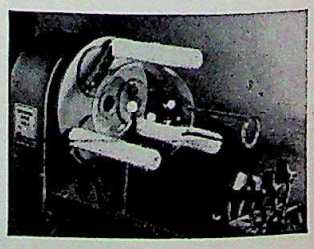

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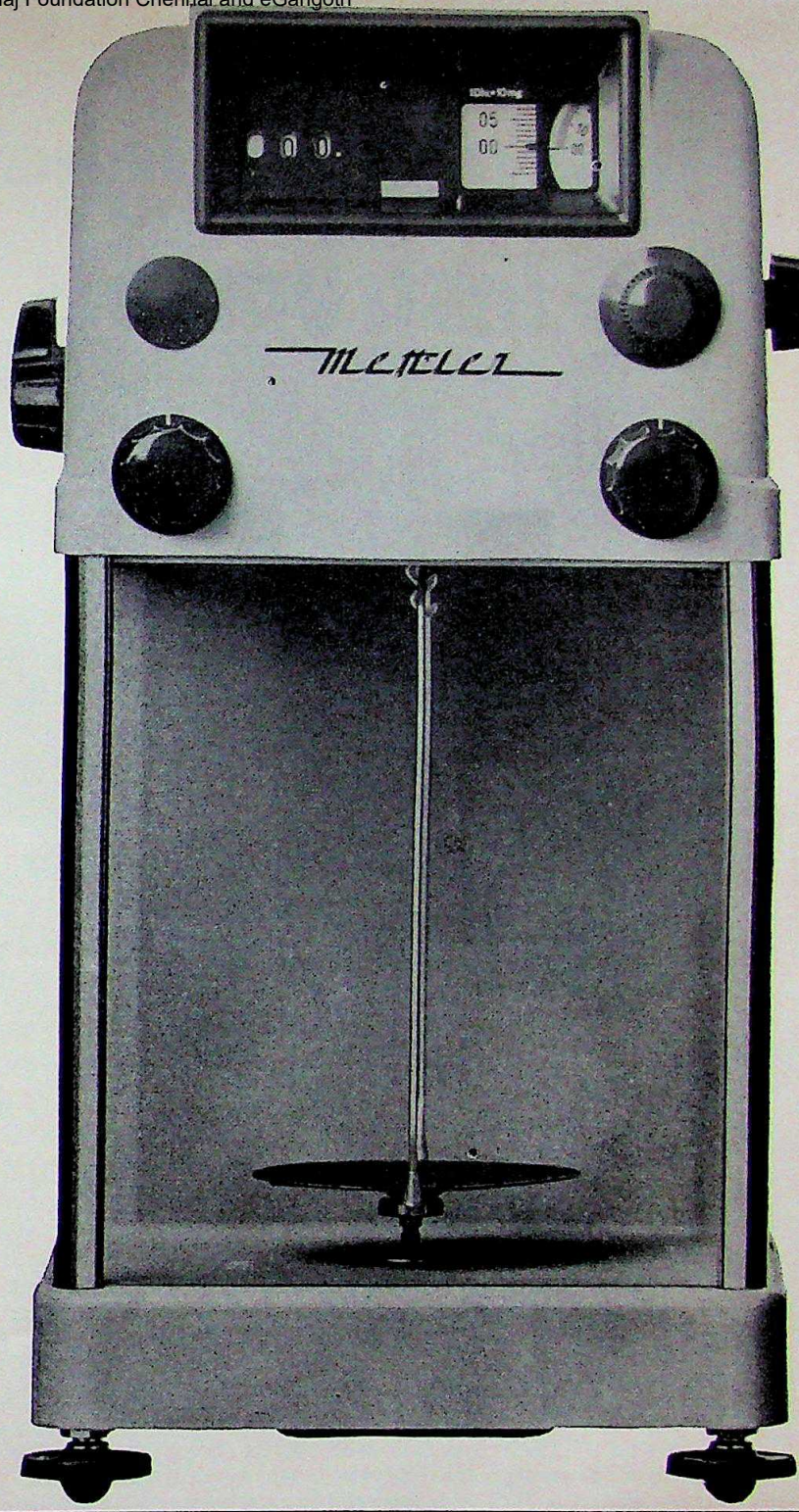

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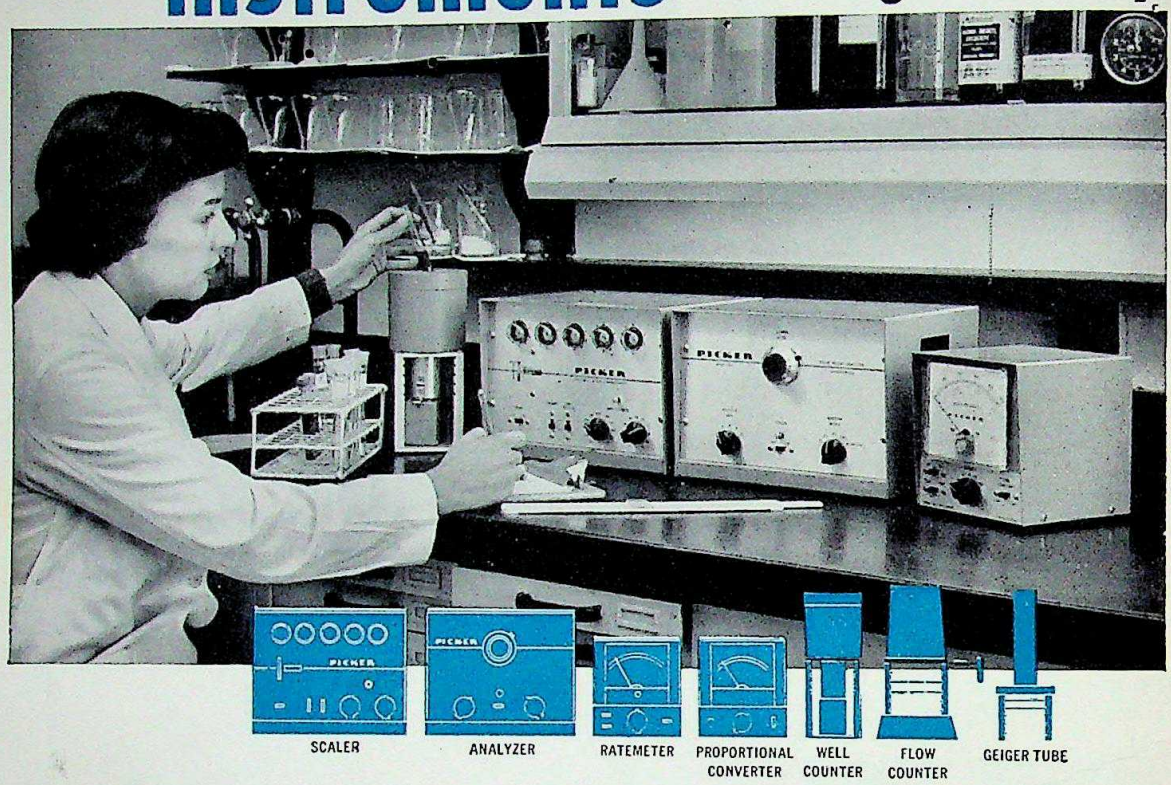

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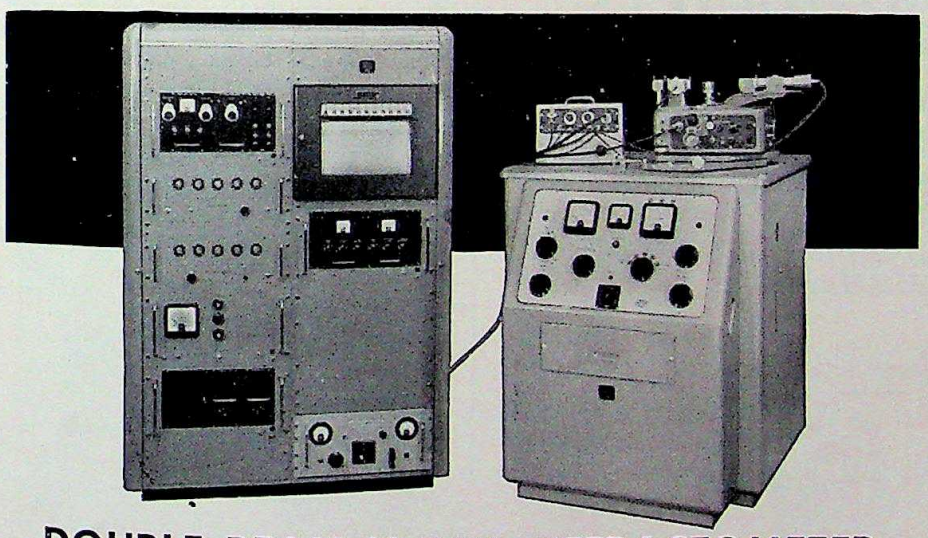
the emitted spectral line of an element is influenced by the matrix, i.e., the other elements constituting the bulk of the sample. For example, in the analysis of a 24S aluminum alloy containing approximately 5% copper, 1.5% magnesium, and smaller amounts of iron, silicon and manganese, standard samples of 24S alloys analyzed by wet chemical methods must be available if an accuracy of 5% is required. Other alloys such as types 2S and 3S containing only 0.10% copper would not be suitable as standards for a 24S alloy. The spectrographer, therefore, requires a large number of standard samples of known composition. It should be pointed out that the ultimate absolute accuracy of any quantitative spectrographic analysis is dependent upon the accuracy of the wet chemical analysis. Thus, in this era of complex chemical instrumentation, the importance of wet chemical analysis should not be overlooked.

In quantitative analysis many variables come into play. The source of excitation, usually a high voltage spark, must be carefully controlled. In the case of solid samples such as metal discs the surface must be carefully machined and the distance of the electrode to the surface of the sample is important. Proper focus of the emitted radiation on the slit of the spectrograph must be made for each exposure. Another important variable is involved in the photographic process. It is necessary to relate the blackening of the photographic plate (i.e., the line density) to the intensity of the light emitted at the source. Since there is no exact mathematical equation relating image density and the intensity of light producing the image, it is necessary to express this relationship graphically and even then the intensities obtained from the graph are relative rather than absolute values. Each batch of photographic emulsions must be calibrated by one of several alternate methods (*6,7*). One method of controlling many of the variables is to use the well established internal standard technique. Rather than measuring just the density of the line of the element to be determined and relating this to the concentration of the element, a second line of an element whose concentration in the matrix is fixed, i.e., an aluminum line in an aluminum sample or an iron line in a steel sample, is chosen as an internal standard and the intensities of both lines are measured. The logarithm of the intensity ratio is then plotted against the logarithm of concentrations as shown in Figure 3 to obtain a standard calibration curve. Thus, variation in the sparking, or developing procedure could change the absolute intensity of each line but not the intensity ratio.

The microphotometer or densitometer is used to measure the blackening of the photographic emulsion. The blackening is related to the emitted intensity and thus to the concentration of an element. The measurements are made in terms of the

(*Continued on page A934*)



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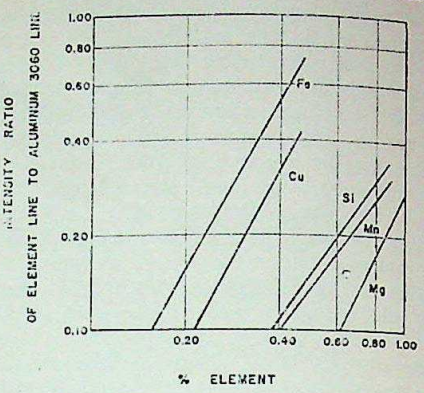

Figure 3. Typical calibration curve for quantitative analysis.

galvanometer or recorder pen deflection, the clear emulsion usually rated as 100 and complete opacity rated as 0.

The essential parts of a photoelectric microphotometer include a source of light (tungsten lamp), a slit to select the desired portion of the emulsion, a holder for the plate, a phototube, and a circuit and scale for reading the photocurrent. Other features include a magnifying or projection system for viewing a reasonable portion of the spectrum, a wavelength scale for locating the lines, and a means of moving the plate horizontally (scanning) across the slit field to obtain the scale reading, and vertically (racking) to move from one spectrum to another. In all instruments available commercially, the maximum excursion of the galvanometer or pen is read as the line is scanned. A typical commercial densitometer is shown in Figure 4.

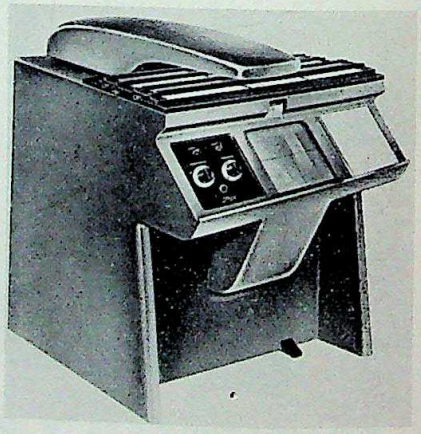

Figure 4. The Jaco densitometer.
(Courtesy Jarrell-Ash Company)

If a microphotometer is not available, rough quantitative results can be obtained with the log sector method. A log sector is a rotating sector placed in front of the slit. It is shaped in such a manner that the slit is illuminated logarithmically along its length as the sector rotates at high speed. The line shapes produced are shown in Figure 5. At some point along the line image, the illumination will be below the threshold intensity and the line will fade out. Hence, the length of the line image gives a measure of the source intensity at that wavelength.

(Continued on page A936)

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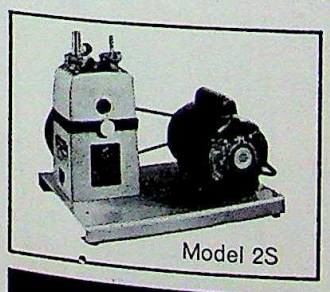
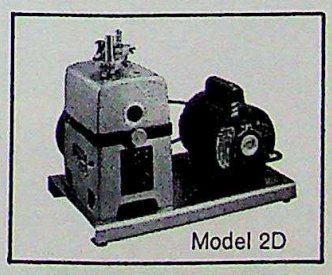

Model 2S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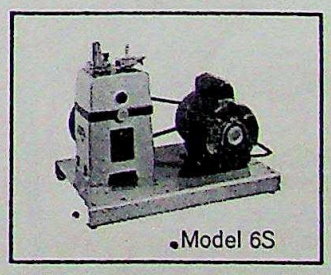
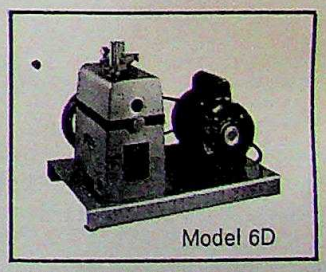

Model 6S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The emulsion calibration and analytical curves are prepared in a manner similar to that employed when line densities are measured except the values of the lengths of the lines are used in place of the logarithms of the deflections obtained on the densitometer. The internal standard technique is also involved. Ratios of line heights of the element being determined to that of an internal standard element are used rather than absolute line heights.

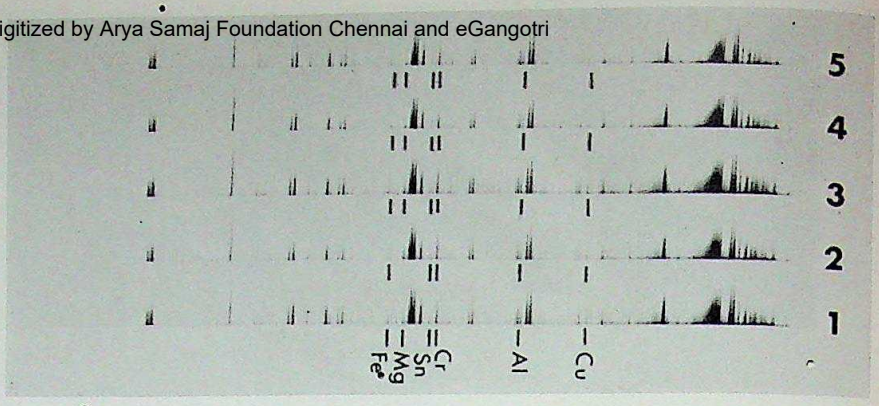

Figure 5. Typical spectra obtained on an aluminum alloy with the log sector method. The lines of selected elements are indicated.

Excitation Sources

The function of an excitation unit is to introduce the sample into the discharge in a vaporized form and to excite electrons in the vaporized atoms to higher energy levels. With the excited atoms emitting characteristic frequencies giving rise to lines on the film or the photographic plate, it is a reasonable assumption that the intensity of an elemental line in a mixture as viewed on the photographic plate is directly proportional to the number of atoms in the sample. Unfortunately this assumption may seem incorrect because of differing volatilities of the components of the mixture. As previously mentioned a properly chosen internal standard with vaporization properties similar to the unknown element is frequently used in quantitative work. Under these conditions the intensity ratio of unknown to standard will be proportional to the unknown concentration.

The DC arc is a common method of introducing the sample into the discharge. Vaporization occurs as a result of the discharge when the arc is struck and heating caused by the passage of current. The DC arc can be used in semiquantitative work with the sample burned to completion at temperatures ranging from 4000 to 8000°C.

The necessary components for a DC arc are a direct current power supply, a variable resistor and a discharge gap. The arc is a very sensitive method of excitation, because so much of the sample is consumed and excited. Figure 6 shows a circuit of the DC arc in the Baird atomic spectrographic source unit. The rectifier produces a DC current at the gap, and a series of fixed resistance steps and a rheostat allow the selection of any current from 1 to 30 amp. The open circuit voltage available to maintain and stabilize the arc is over 300 v on any step. Most of the elements can be determined by the DC arc with a good line to background ratio.

An attachment frequently used with the DC arc to enhance sensitivity is the Stallwood Jet shown in Figure 7. In the Stallwood Jet of Spex Industries Inc., gas is forced into a swirl chamber and then upward through an orifice surrounding the sample electrode. As the electrode burns, it may be advanced with respect to the curtain of gas. Instead of the gas entering the open atmosphere after leaving the orifice, it enters a quartz enclosure where, by building up a slight positive pressure, air is excluded. The most typical gas used is an argon-oxygen mixture.

(Continued on page A938)

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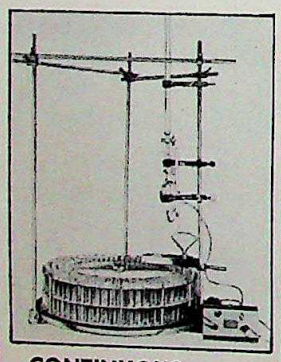

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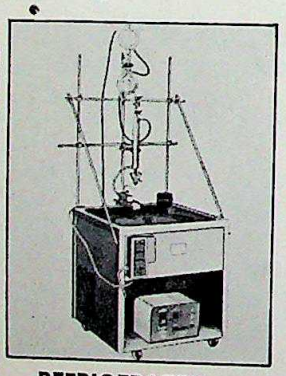

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Enhanced sensitivity is achieved with the Stallwood Jet for two reasons. One is that cyanogen bands are eliminated, and even though raies ultimes depend on the gases used, elements hidden in the cyanogen bands are more easily detected. The sensitivity of molybdenum, the rare earths and iron are considerably enhanced in nitrogen free atmospheres. The second reason for improved sensitivity is that the excitation efficiency of a sample can be markedly increased if it is forced to burn slowly. A volatile material such as arsenic or selenium is detected with marked sensitivity when placed in a deep cratered electrode and burned slowly when cooled with the Stallwood Jet gas stream.

The AC arc is generally more sensitive than the DC arc and can detect elements below the limit of detection of a spark. Although the AC arc lacks the very high analytical precision of the spark, it is more sensitive and is used extensively for trace element determinations. In the Baird-Atomic AC arc shown in Figure 6, the transformer is equipped with two secondary windings to provide either 5 amp at 2750 v (open circuit), or 2.5 amp at 5500 v (open circuit). The gap breaks down as the voltage reaches its peak in each half cycle, and the voltage drops rapidly to 30–80 v and an arc-like discharge occurs until the voltage starts to reverse. The arc is now terminated and reignited on the next half cycle. The arc is stabilized by a ballast resistor and the transformer and the maximum current is limited to 50 amp. The reignition each half cycle on a random part of the material provides a good sampling technique.

The AC spark is the preferred source whenever high precision rather than extreme sensitivity is required. The determination of per cent concentrations of alloying elements in metals is a typical area where the spark source finds extensive applications. The variety of spark sources available all have basically the same secondary circuit consisting of a high voltage capacitor, an inductance, a resistance, and the gap. The various sources mainly differ in the mechanism used to trigger the breakdown of the analytical gap. The oscillatory gap discharge is a damped wave train, with the majority of the power appearing in the first wave. Exceptional precision is obtained because the spark circuit provides a series of discrete and identical breakdowns of the analytical gap. The sample is subjected to a high degree of excitation without excessive heat. The introduction of sample

(Continued on page A942)

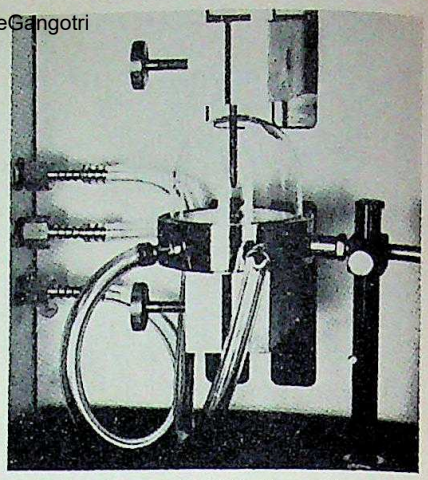

Figure 7. Spex enclosed Stallwood Jet.
(Courtesy Spex Industries, Inc.)

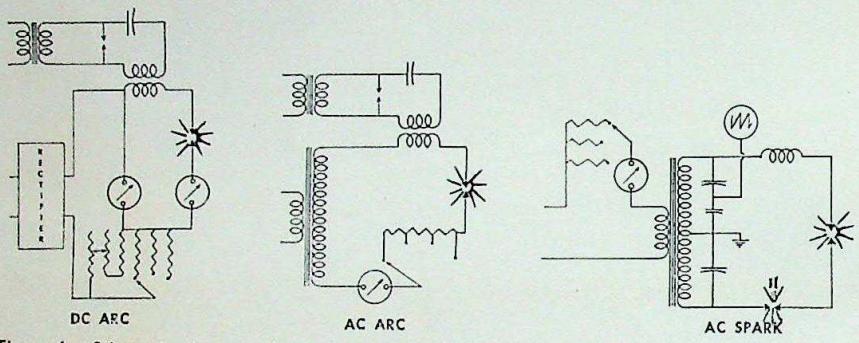

Figure 6. Schematic diagram of dc arc, ac arc and ac spark sources.
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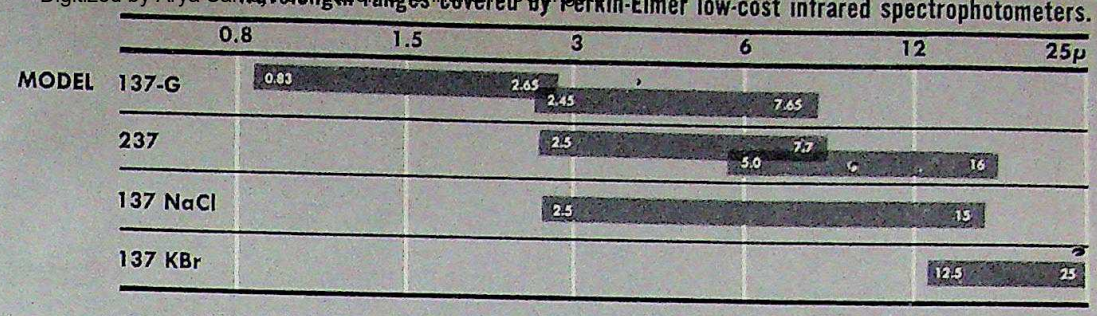

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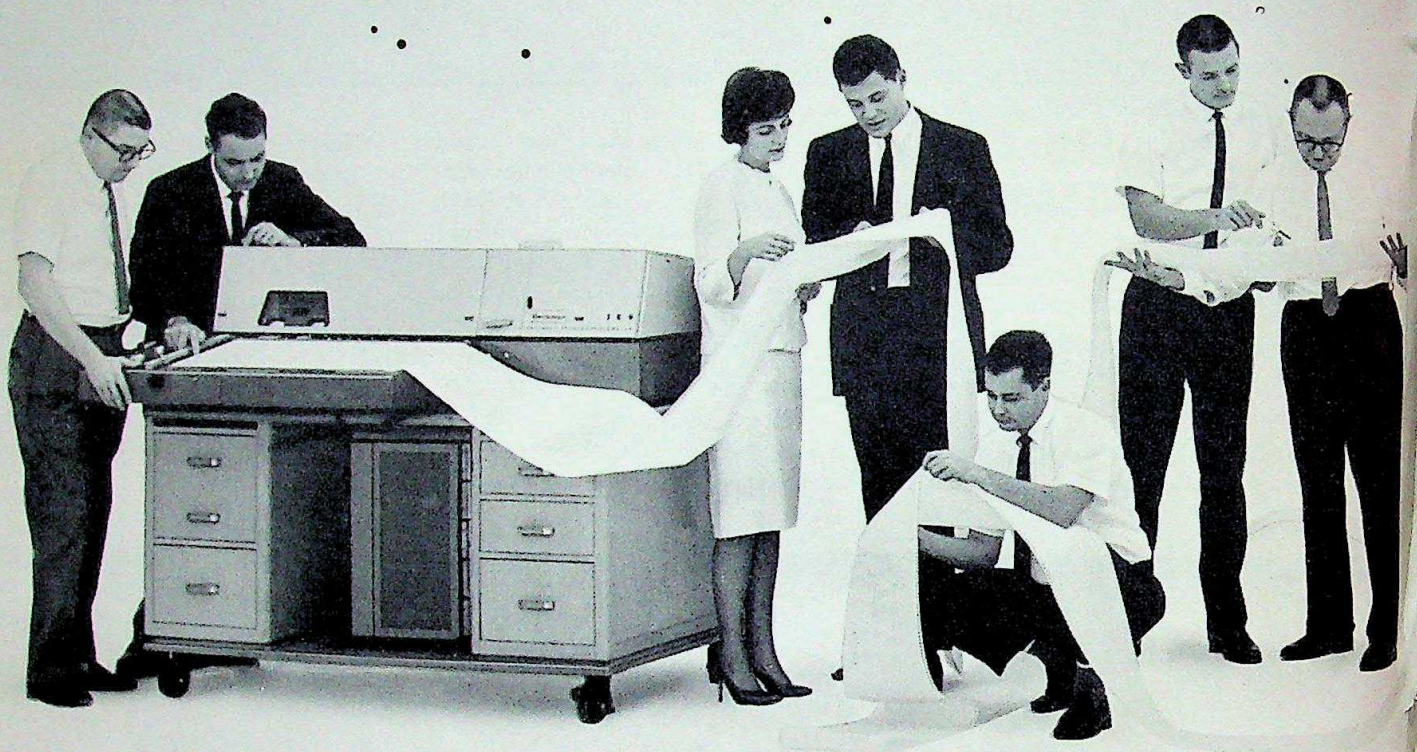

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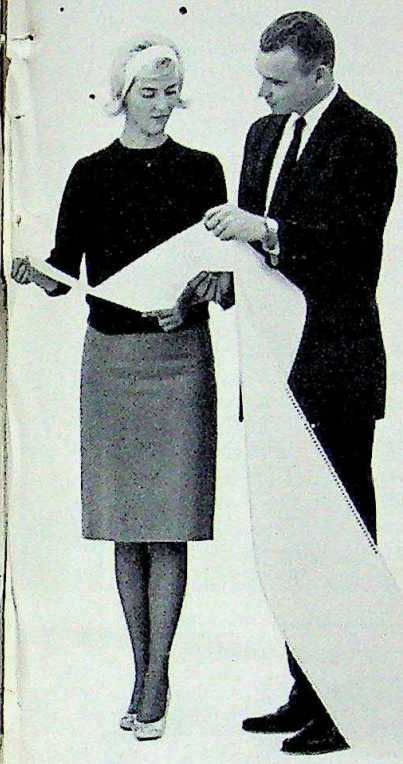

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into the gap by the spark is primarily by ion bombardment of the cathode in the first microsecond when the potential drop across the electrodes is quite high. In the Baird AC spark unit shown in Figure 6, the transformer secondary output is about 25,000 v at 60 cps. During each half cycle, the transformer charges a condenser bank to a sufficiently high voltage to break down the auxiliary gaps and the condensers discharge through these gaps. The spark is quenched by an air blast blowing across the auxiliary gap, and the condensers charge again for another breakdown.

Other companies producing somewhat similar excitation units are Applied Research Laboratories, Jarrell-Ash Company and National Spectrographic Laboratories.

A new excitation source recently developed by the Jarrell-Ash Company is the laser microprobe. A wide variety of materials may be directly analyzed by this source without extensive sample preparation. A schematic diagram of the laser microprobe is shown in Figure 8. The laser beam is concentrated into the sample by a microscope. The intense heat vaporizes the sample which short circuits an auxiliary electrical gap positioned between the sample and microscopic objective. Spectral emission takes place during the short circuit. This method permits a spectrum of the sample to be recorded on a one-shot process.

"Emission Spectroscopy," Part Two, will be concluded in the January 1964 issue. That installment will cover monochromators and typical commercial instruments.

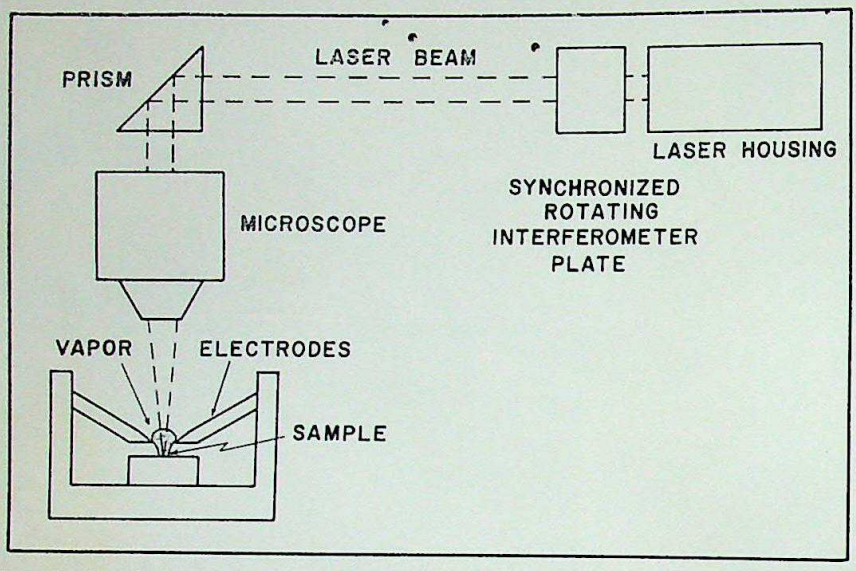

Figure 8. Simplified drawing of the Jarrell-Ash laser microprobe.

NOTE

The Editors will be pleased to discuss possible contributions to this series with potential authors who feel they have a paper of this type on an appropriate theme. A prospective author is asked to check annual indexes to note topics already treated and to be familiar with the general style and format of the papers. Inquiries should be addressed either to Professor S. Z. Lewin, New York University, New York 3, N.Y. or to The Editor, W. F. Kieffer, Dept. of Chemistry, Room 6-123, Massachusetts Institute of Technology, Cambridge 39, Mass.

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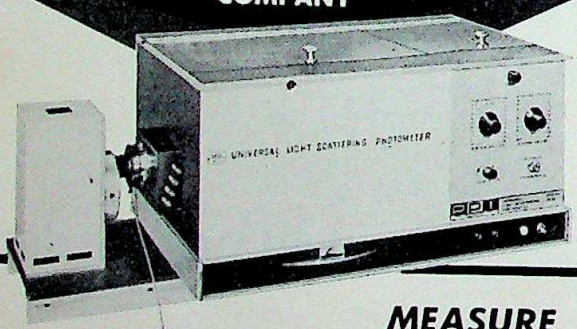

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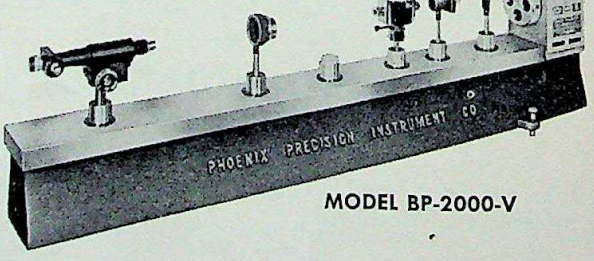

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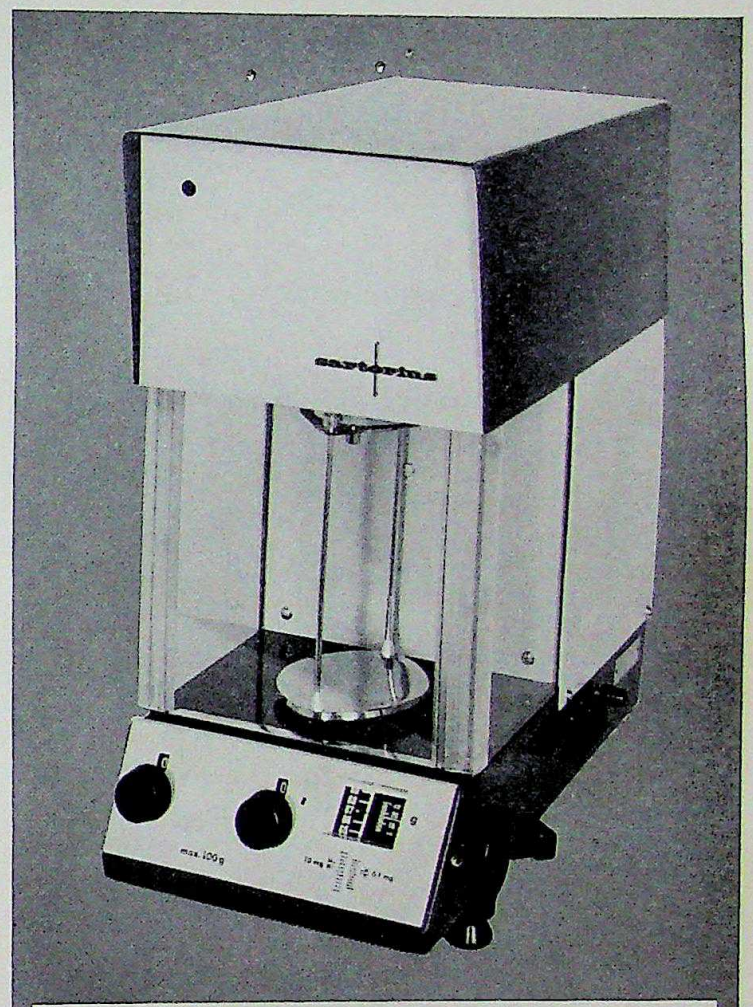

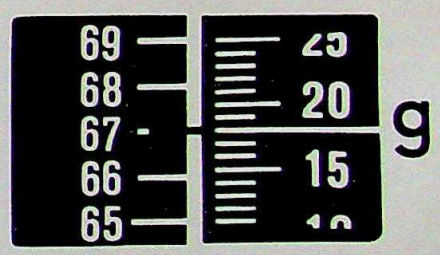

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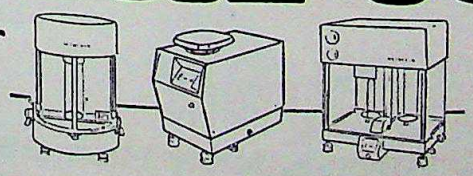

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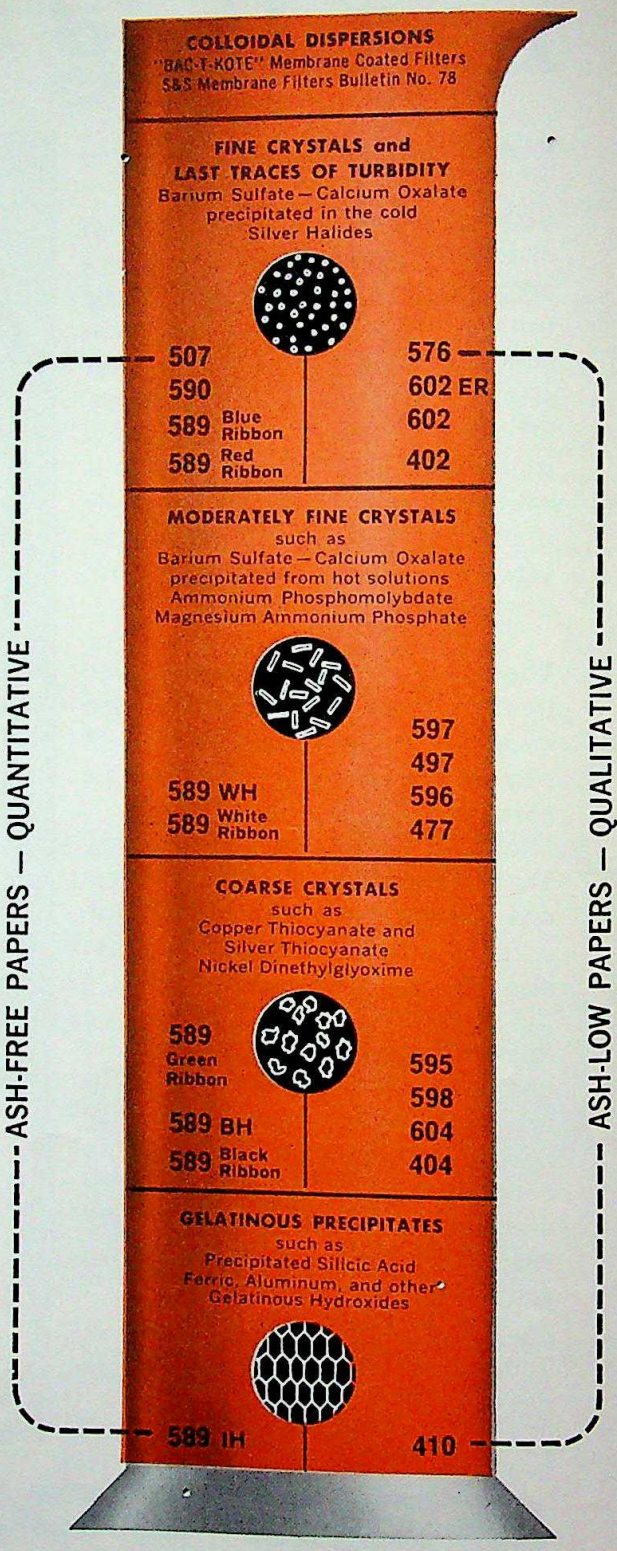

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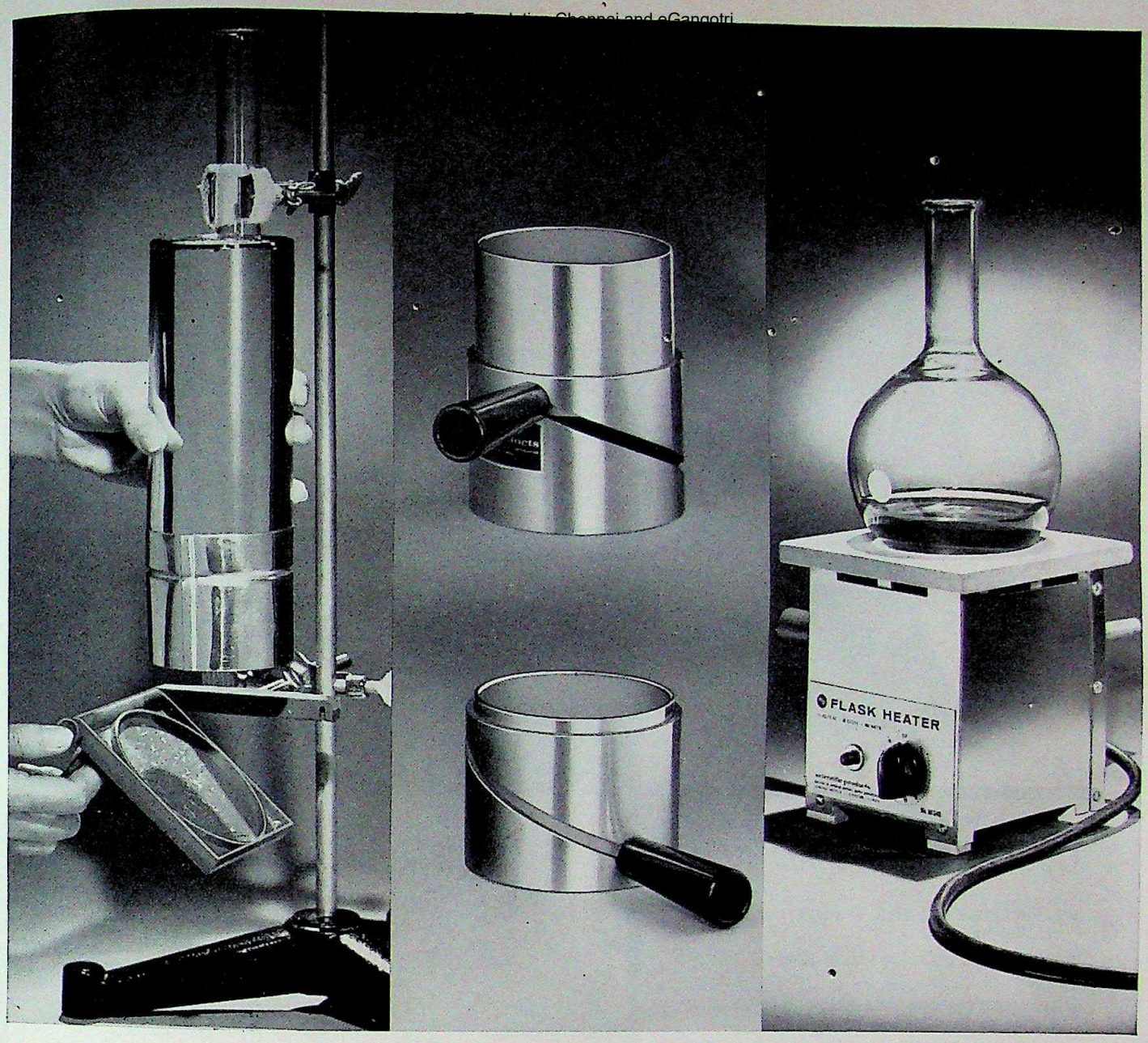

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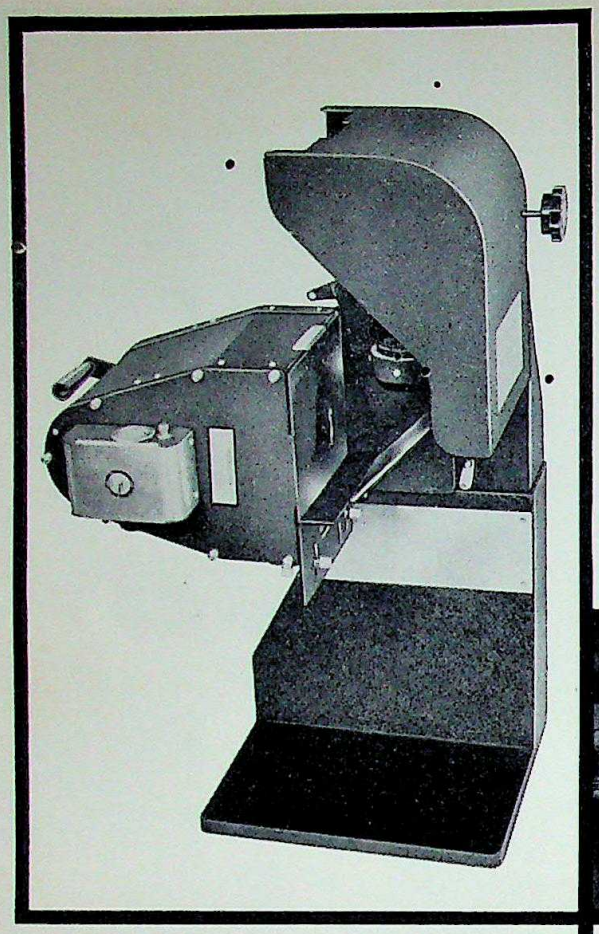

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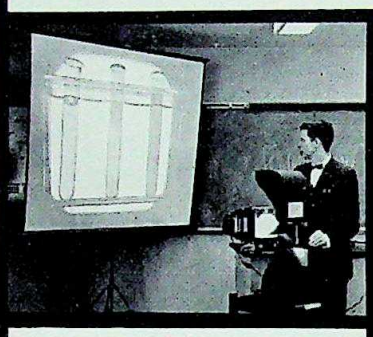

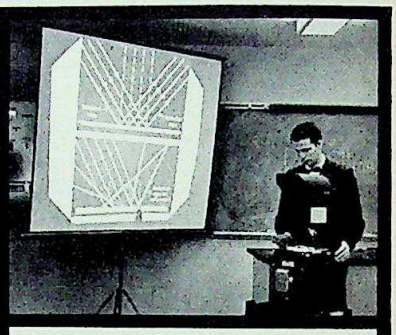

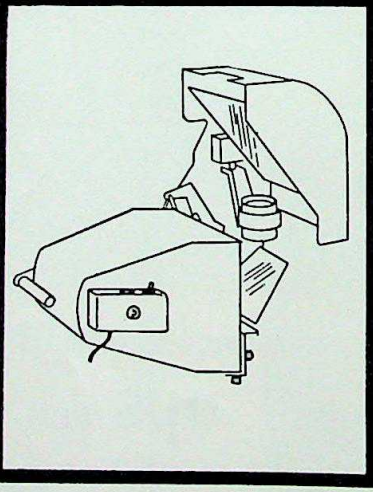

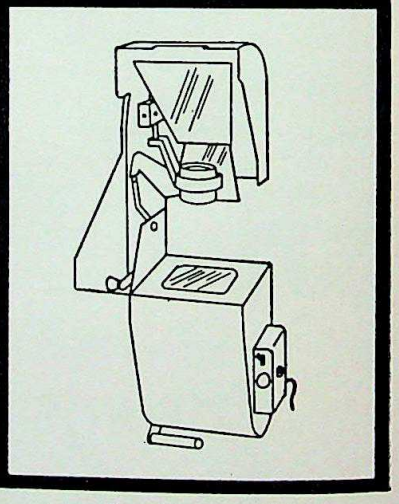

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3. CHEMICAL REACTIONS OF WATER *(continued)*

Dem. 107—Heat of Hydration of H_2SO_4

(Experiment developed by Lilias Brescia, LeRoy Hornbeck, Fred Rolf.)

To show: Heat is evolved when conc. H_2SO_4 is mixed with water. ($H_2SO_4 + H_2O \rightarrow H_2SO_4.H_2O$, the monohydrate forms).

Method 1.

Materials: M°, conc. H_2SO_4, dropper.

Procedure: Project M° with box two-thirds full of water. Suddenly squirt a ml or more of conc. H_2SO_4 into the water, taking care not to squirt it against the plastic (would damage it).

Observation: There is rapid, dramatic rise in temperature.

Notes: *1.* "The water should be in before you add the H_2SO_4; or else you might not feel too well; you might not even live to tell."

2. "If you're doin' what you oughter add the acid to the water; May your rest be long and placid, adding water to the acid."

Method 2.

Materials: Ether, iodine, H-3, conc. H_2SO_4, 6 mm tubing 6-in. long, cork stopper, epoxy cement.

Preparation: Seal one end of the tubing. Quarter fill it with ether containing enough iodine to project clear brown. Push in the cork and fill the upper $^1/_4$-in. of the 6 mm tube with epoxy-cement. (*Note:* do not seal at both ends, this cementing technique is much safer and simpler.)

Proceedings: Place a culture tube in H-3 and project. One-quarter fill it with conc. H_2SO_4. Cautiously (CARE) pour an equal volume of water so it rests on the acid. Now insert the ether-iodine rod and (CARE) stir.

Observations: The violent evolution of heat from the hydration of the acid is sufficient to cause the ether to boil vigorously.

Notes: *1.* This is safer than Tested Demonstration No. 4-11, where an open tube is used and the boiling ether is ignited. The flame would not be visible on the projector.

2. Lay the ether-iodine stirring rod away for reuse, it keeps indefinitely.

3. Also (*a*) methanol with methyl red, or (*b*) carbon disulfide with iodine can be used.

B. ACIDS, BASES

1. PREPARATION OF ACIDS AND BASES

Dem. 108—Acid Anhydrides

To show: The preparation of acids from acid anhydrides.

Materials: Phenolphthalein indicator, H-1 with a straight not curved-up delivery tube, dry ice, Cu wire, conc. HNO_3, NaCl, conc. H_2SO_4, $NaHSO_3$, dil. H_2SO_4, P_2O_5, five 4-in. culture tubes, dil. NaOH-aq.

Procedure: To 100 ml water add a few drops of phenolphthalein plus a drop of very dilute NaOH to make the solution distinctly red. Fill the culture tubes half-full of this solution. Set one in H-1 and project. (*a*) *Carbonic acid.* Drop a lump of dry ice into the red solution. (*b*) *Nitric acid.* To $^1/_5$th a tube of conc. HNO_3 in the generator H-1 add a Cu wire. Bubble the off-gas into the red solution. (*c*) *Hydrochloric acid.* Ditto, with NaCl + conc. H_2SO_4. (*d*) *Sulfurous acid.* Ditto, with $NaHSO_3$ + dil. H_2SO_4. (*e*) *Ortho-phosphoric acid.* Add a pinch of solid P_2O_5 to the red solution.

Observations: Each solution turns colorless as the acid anhydride dissolves in the water to form an acid, viz. H_2CO_3, HNO_3 + NO, HCl, H_2SO_3, and H_3PO_4.

Note: It is also instructive to start with sulfur and burn it in air, then dissolve the remaining material (enough SO_2 remains on the sulfur) in the phenolphthalein solution. Ditto, red phosphorus.

Dem. 109—Basic Anhydrides

To show: The formation of bases from basic anhydrides.

Materials: CaO, old lump of Na, phenolphthalein indicator solution, cell C-2.

Procedure: Two-thirds fill the chambers of C-2 with water and add a drop of very dilute indicator to each. (*a*) Add a pinch of CaO to one. (*b*) Scrape off *only* the white coating on a lump of sodium, explaining to the class that it is a mixture of sodium oxide and peroxide. Be sure not to have any sodium in the scrapings. Drop into the other chamber.

Observations: Both form hydroxides ($Ca(OH)_2$ and NaOH) and turn the indicator red.

Dem. 110—Formation of an Hydroxide by Electrolysis

To show: The formation of potassium hydroxide by the electrolysis of KI-aq.

Materials: E-1 with U-tube and short Pt electrodes, KI-aq. containing a drop of phenolphthalein indicator.

Procedure: Fill the U-tube with the solution; insert in E-1, and insert the Pt electrodes. Project. Switch on the current. After a few minutes, reverse the current.

Observations: (*a*) Brown iodine forms at the positive pole, and sinks in a streamer into one limb. KOH forms at the other pole and turns the indicator red. (*b*) Reversing the current reverses the effect.

Dem. 111—Electrolytic Writing

(Experiment developed by Edwin H. Cooper.)

To show: Formation of a base during electrolysis.

Materials: 5 × 5-in. Al foil, 5 × 5-in. blotter or heavy filter paper, 5 × 5-in. glass plate; KI, gelatin, soluble starch, ethyl alcohol, phenolphthalein, 45-v source (e.g., Burgess 230 Nx 45 v), 6 mm tubing, No. 18 Cu wire, insulated Cu bell wire.

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Preparation: (*a*) *"Liquid write"*. Make starch solution from 0.8 g starch made into paste and added to 20 ml boiling water. Make indicator solution from 0.8 g phenolphthalein + 10 ml water + 10 ml ethyl alcohol. To 80 ml saturated KI-aq. add the starch and indicator solutions (add more alcohol if the solution remains cloudy). Now stir in, gradually, 12 g gelatin, and warm the solution until the liquid is a uniform tannish color. Cool. (*b*) *Writing styluses*. Jamb a No. 18 Cu wire through a 6 mm tubing 15 cms long. Solder one end to thinner insulated wire (bell wire). Make a second stylus. Connect the two to the 45-v battery. (*c*) *Writing surface*. Cut a $4^1/_2 \times 4^1/_2$-in. square out of the Al foil so as to make a 5 × 5-in. frame $^1/_2$-in. wide. Moisten the paper and place it on the glass, then press the Al foil frame snugly upon the paper.

Procedure: Spread two or three drops of "liquid write" over the blotting paper on the plate, making sure the solution touches the edge of the Al strip. Touching one stylus to the Al frame, "write" in the solution with the other stylus.

Observations: The negative stylus will write red ($2H_2O + 2e^- \rightarrow H_2 + 2OH^-$), whereas the positive stylus will write darkly (first the iodine is liberated, $2I^- \rightarrow I_2 + 2e^-$, then the iodine reacts with the starch to give a blue-brown color). The moist paper is translucent.

Notes: *1.* To erase, rub the finger over the solution, which is then ready for more writing.

2. Although this will work without the Al foil frame, by placing both styluses on the "liquid write," the immobile stylus leaves an undesirable mark. (Cooper)

Reference: Oxidation and Reduction of Ions at Electrodes, GILETTE, COL. E. C., JR. *J. Chem. Educ.*, **34**, A209 (1957).

2. SOLUBILITY OF ACIDS AND BASES

Dem. 112—Solubility of HCl in Water

(*Experiment developed by Alphonse Palermo.*)

To show: The extremely rapid dissolving of HCl gas in water.

Materials: Four-inch culture tube, a 3 × 1 × 1-in. clear plastic trough, conc. HCl, conc. H_2SO_4, Ehler's green food color or any acid-base indicator.

Procedure: Project trough two-thirds full of water tinted green. Put a dropperful of conc. H_2SO_4 in the culture tube. Carefully run a dropperful of conc. HCl upon this. *At once* invert in the trough of water. (Wash acid off of thumb!)

Observation: After a five-second delay the tube fills with HCl gas, and water rises to nearly fill the tube. The food coloring turns yellow.

Reference: ARENSON, S. B., for CHANDLER, E. E., **17**, 513 (140).

Dem. 113—The Ammonia Fountain

To show: The rapid dissolving of ammonia in water, to give a fountain effect.

Materials: Phenolphthalein indicator, conc. NH_4OH, test tube with one-hole stopper carrying a 5-in. length of 6 mm tubing, burner, 3 × 1 × 1-in. clear plastic trough, square 1-oz dropper bottle, the upper third of its rubber bulb cut off diagonally.

Procedure: See Diagram 113. Project with the trough nearly full of water containing a few drops of indicator. Generate NH_3 gas by boiling conc. NH_4OH in the test tube and fill the dropper bottle by inverting it over the 6 mm delivery tube. Slightly warm the bottle by passing it momentarily through the flame. *At once* invert in trough with cut rubber bulb under the water.

Observations: In a minute the bottle cools slightly. This creates a slight vacuum in the bottle, which sucks a little water into the bottle. At once NH_3 dissolves in the water creating a considerable vacuum, and the water spurts up as a lively fountain. As the NH_3 dissolves, the phenolphthalein turns red.

Note: Instead of using the normal glass dropper, as shown in the figure, a variation is to draw it into a nozzle only 1-in. long. When this is used, the water that sucks in quickly covers the nozzle, but the fountain still persists, rushing up *through* the water and spouting lively in the rapidly-filling bottle.

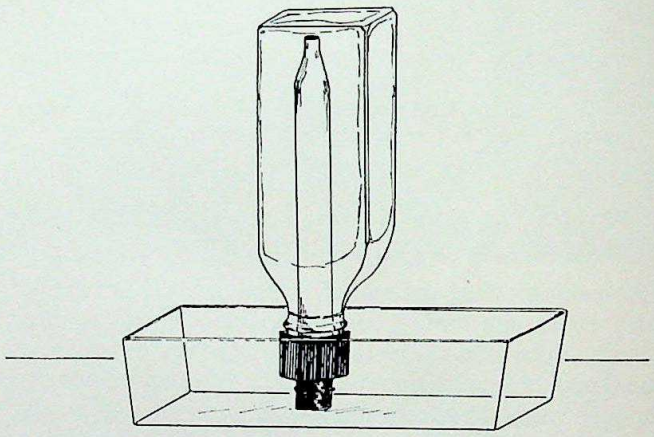

Figure 113. The ammonia fountain.

Dem. 114—Insoluble Hydroxides

To show: The formation of insoluble hydroxides.

Materials: 1 Molar aqueous solutions of NaOH, $FeCl_3$, $FeSO_4$, $CuCl_2$, $CoCl_2$, $NiCl_2$, $ZnCl_2$, $AlCl_3$; cell C-3, stirrer.

Procedure: Use the following very dilute solutions. Fill the culture chambers of C-3 two-thirds full of water, then add reagent as indicated, finally adding the NaOH dropwise to precipitation. Stir toward end of reaction. (*a*) Two drops $AlCl_3$. (*b*) Six drops of $FeCl_3$ or of $FeSO_4$. (*c*) Two dropperfuls of $CuCl_2$, $NiCl_2$, or $CoCl_2$. (*d*) Quarter of a tubeful of $AlCl_3$.

Observations: Good precipitates form. Those with Zn^{++} and Al^{+++} redissolve when excess NaOH is added.

Note: If the dropper containing the NaOH is immersed in the solution, the formation is oftimes more colorful, as the color spreads out from the nozzle of the dropper.

3. REACTIONS OF ACIDS AND BASES

Recall the actions of acids on metals (Dem. 70) and of Al on hydroxides (Dem. 75).

Topic "Water, Acids, Bases, Salts" continued in January 1964 issue.

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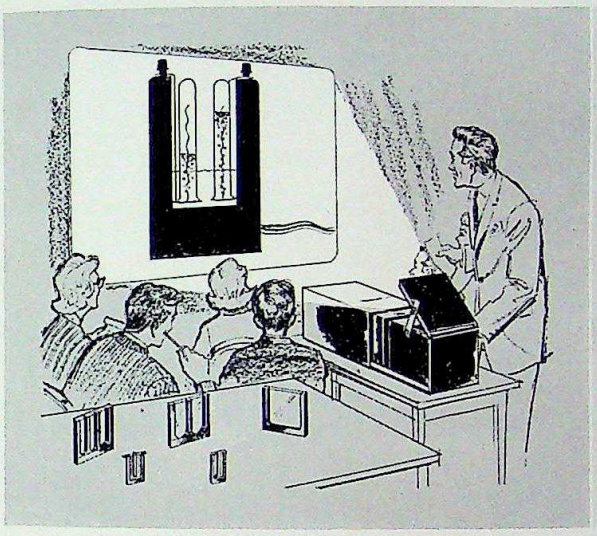

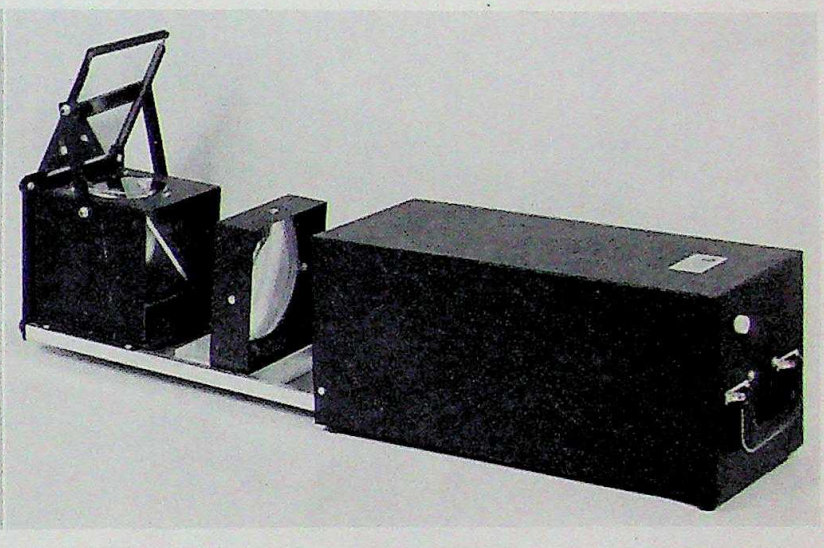

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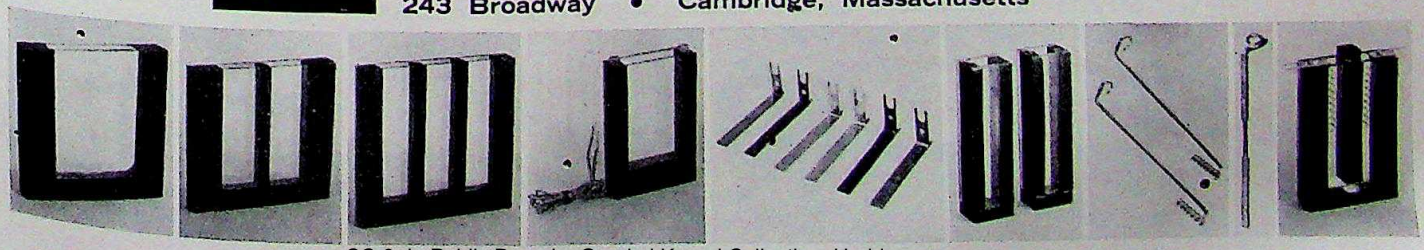

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Chem Ed

Out of the EDITOR'S BASKET

Edited by William G. Kessel

When writing for additional information about new products or for new literature, your inquiry will receive prompt attention if you write on your firm or Institution letterhead and mention the Journal of Chemical Education and the date of the particular issue. Pamphlets, booklets and similar literature are gratis unless otherwise specified.

New Apparatus and Equipment

▶ A special resealable, pressure-release vent is incorporated in a new reduced cost, rechargeable, nickel-cadmium battery, the DR-120 cell, introduced by Gulton Industries, Inc., 212 Durham Ave., Metuchen, New Jersey. Physically it is interchangeable with standard "D" size cells.

▶ Barnstead Still and Sterilizer Co., 168 Lanesville Terrace, Boston 31, Massachusetts, announces the development and introduction of the Barnstead "85" automatic distilled water center consisting of Still with exclusive high purity features and totally enclosed as a cabinet model occupying exactly 36 in. of wall space with work counter at dado height.

▶ Phoenix Precision Instrument Co., 3803–05 N. Fifth St., Philadelphia 40, Pennsylvania, announces its new Model K8000-B a completely self-contained, yet most accessible, instrument for automatic separation, identification, and quantitation of amino acids and related compounds. It features a new dual-speed strip chart recorder for operation with new Accessory 8800-B Accelerated Analysis System, which allows three complete protein or peptide hydrolysate analyses per day.

▶ Laboratory Furniture Co., Inc., Mineola, Long Island, New York, offers the Series FH-300 fume hoods designed to reduce laboratory air conditioning and heat losses.

▶ For nuclear magnetic resonance spectroscopy a new low-cost digital computer, the Mnemotron Cat 400 (NMR), using the averaging technique greatly increases signal-to-noise ratio. Write for *Technical Application Bulletin No. 3* to Mnemotron Division of Technical Measurement Corp., 202 Mamaroneck Ave., White Plains, New York.

▶ For complete data on the rack-mounted V.O.M.-5 Strip Chart Recorder write for *Bulletin D-2046*, Bausch and Lomb Inc., Rochester 2, New York.

▶ Schoeffel Instrument Co., 355 Hillsdale Ave., Hillsdale, New Jersey, offers the new TM 100 Motion Transducer. Descriptive bulletin is available.

▶ A thermoelectric Immersion Cooler which weighs $2^1/_3$ lb is $12 \times 2^3/_4 \times 1^1/_8$ in. and can be successfully used as an "inside-out" refrigerator. Information is available from Whirlpool Corp., Benton Harbor, Michigan.

▶ A new low cost method, the PLE-400 Paper Chromatograph for accurate quantitative analysis of organic or inorganic fluids in industrial, food processing, medical, and many other fields of chemical laboratory work is announced by Possis Machine Corp., 825 Rhode Island Ave., Minneapolis 26, Minnesota.

▶ The American Agile Co., 5461 Dunham Rd., Cleveland 37, Ohio, has just announced a new line of "Agile Vaneaxial Fans." These high-performance, corrosion-proof, long-life fans are the result of two years of intensive research by the company's air engineers and plastics engineers. Constructed of fire retardant, highly chemical resistant polyester resin, they are competitively priced even with ordinary steel fans.

▶ Mixing Equipment Co., Inc., Mt. Read Blvd., Rochester 3, New York, has expanded its line of continuous Lightnin

(*Continued on page A953*)

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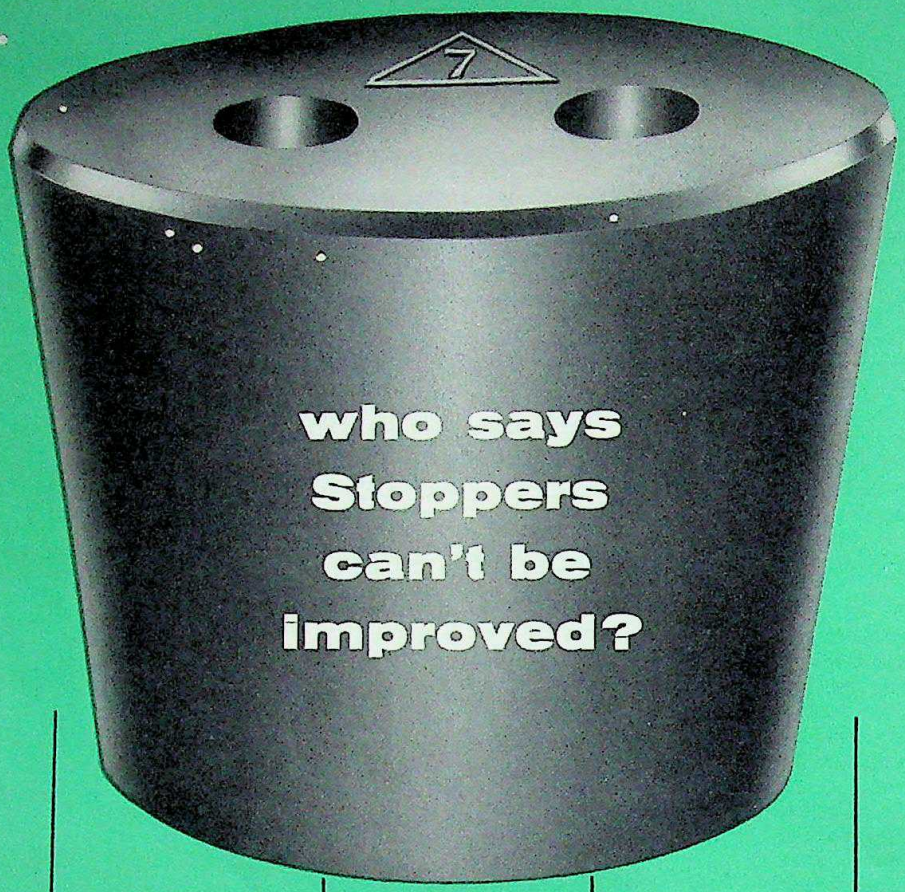

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Out of the EDITOR'S BASKET

Line Blenders to include a model for pilot plant or laboratory use. The units, which are available with Lucite tanks for visual studies, produce the same process results as their larger counterparts.

▶ A new low cost infrared spectrophotometer—the first in its class to offer variable slit programing—has been introduced by Perkin-Elmer Corp., Main Ave., Norwalk, Connecticut. The new Model 237B gives the chemical analyst widest possible flexibility in adapating to the requirements of analysis.

▶ A new drum-and-stylus recorder which shows when a given laboratory operation begins and ends has been announced by Henry Troemner, Inc., 22nd and Master Sts., Philadelphia 21, Pennsylvania. Through a display of working time and downtime, the new instrument is said to provide valuable information for the improvement of laboratory work habits and schedules.

▶ A modular gas chromatograph, the Aerograph Hg-FI_2 one of a new Moduline Series, which offers the chemist precisely the instrument of his choice, has been announced by Wilkens Instrument & Research., P.O. Box 313, Walnut Creek, California.

▶ A new line of high temperature, high vacuum furnaces has been announced by the Vacuum Products Division of Varian Associates, 611 Hansen Way, Palo Alto, California. These cold-wall furnaces maintain a pressure of 5×10^{-9} torr while at temperatures above 2000°C. The furnace system rapid-cycles to 5×10^{-8} torr in two hours, and base pressures are below 5×10^{-10} torr.

▶ The new "Widebeta" and "Lowbeta" II radioactivity counting systems, developed by Sharp Laboratories, are now being marketed by the Scientific and Process Instruments Division of Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, California. Representing an additional capability for Beckman in the nuclear products field, the systems combine the most recent advances in high sensitivity, low background alpha and beta counting instrumentation.

▶ Detailed technical data concerning Crystalab Deem-a-Flow Series 400 and 500 demineralizers is available upon request. Write to Crystal Research Laboratories, Inc., 29 Allyn St., Hartford 4, Connecticut.

▶ The Micro-V magnetic stirrer with planetary gear-head motor, ideal for setup frames and racks, is announced by Cole-Parmer Instrument and Equipment Co. 7330 N. Clark St., Chicago 26, Illinois. Measuring only $2^3/_4$-in. square and 5-in. high, the stirrer is designed to fit handily in small spaces.

(*Continued on page A959*)

A Laboratory Glass Cutting Unit
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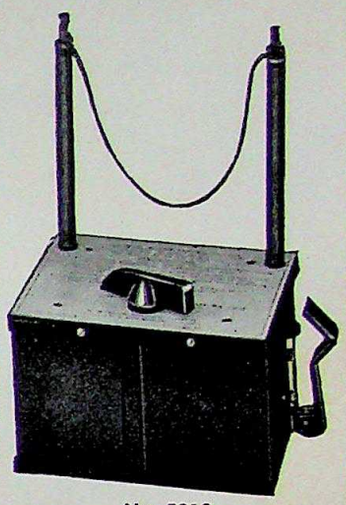

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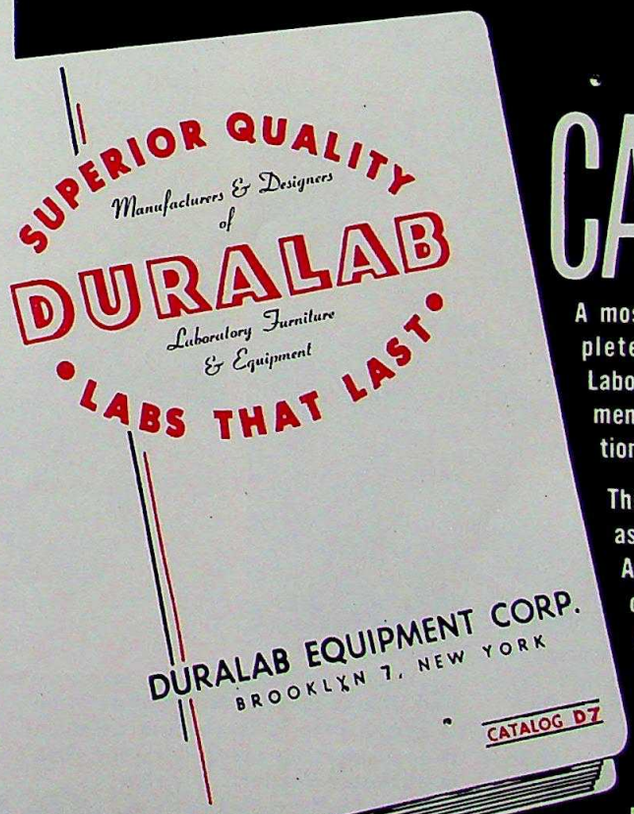

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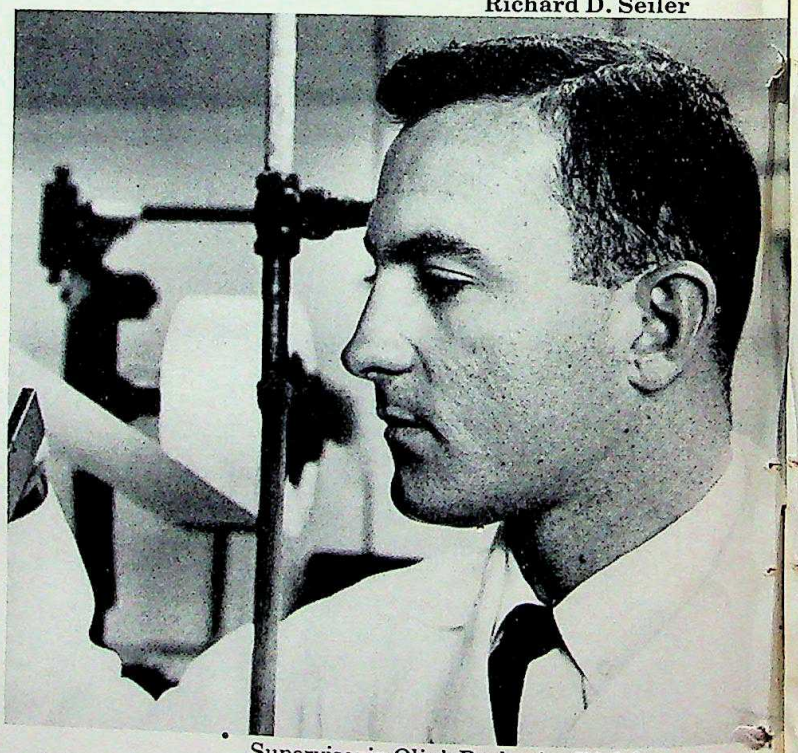
What happened to the Class of '60?

Harlan Marsh Baxter

Jerry Dale Shay

James P. Silver

Richard D. Seiler



Harlan Baxter is with Olin's Chemicals Division, developing commercial applications for the new wonder-fuel, hydrazine.

(We're working on new products that would make an alchemist scoff in disbelief.)

Jerry Shay was recently promoted to Technical Advisor in Olin's Metals Division.

(We're moving so rapidly, we haven't had time to master the art of red tape.)

Jim Silver is designing ammunition processing machinery for Olin's Winchester-Western Division.

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Richard Seiler is a Research Supervisor in Olin's Packaging Division.

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Right now, Olin is looking for the class of the Class of '64. For complete information, the man to contact is Monte H. Jacoby, College Relations Officer, Olin, 460 Park Ave., New York 22, N.Y.

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▶ A new precision solid-state scaler, SC-520 Series, has been introduced by the Tracerlab Division of Laboratory For Electronics, Inc., 1601 Trapelo Rd., Waltham 54, Massachusetts. The new scaler features high-voltage power supply, decade scaler, electronic timer, and data readout. The Series SC-520 Omni/-Guard Scalers feature anticoincidence circuitry which permits the lowest possible background count.

▶ A line of 11 corrosion-resistant stainless steel sample, one and two valve cylinders are offered by The Matheson Company, Inc., P.O. Box 85, East Rutherford, New Jersey. They are fabricated from 304 stainless steel, finely machined, ICC approved and suitable for the sampling, transportation, and storage of products under pressure.

▶ Unicam Instruments, Ltd.'s new Sp. 200 Infrared Spectrophotometer provides the ultimate in performance, speed, and reliability in the low cost infrared field. The SP. 200 is the only spectrophotometer in its price range with a variable slit program, or program energy control. For complete information, write either: Unicam Instruments, Ltd., Cambridge, England, or Wilkens-Anderson Co., 4525 W. Division St., Chicago 51, Illinois.

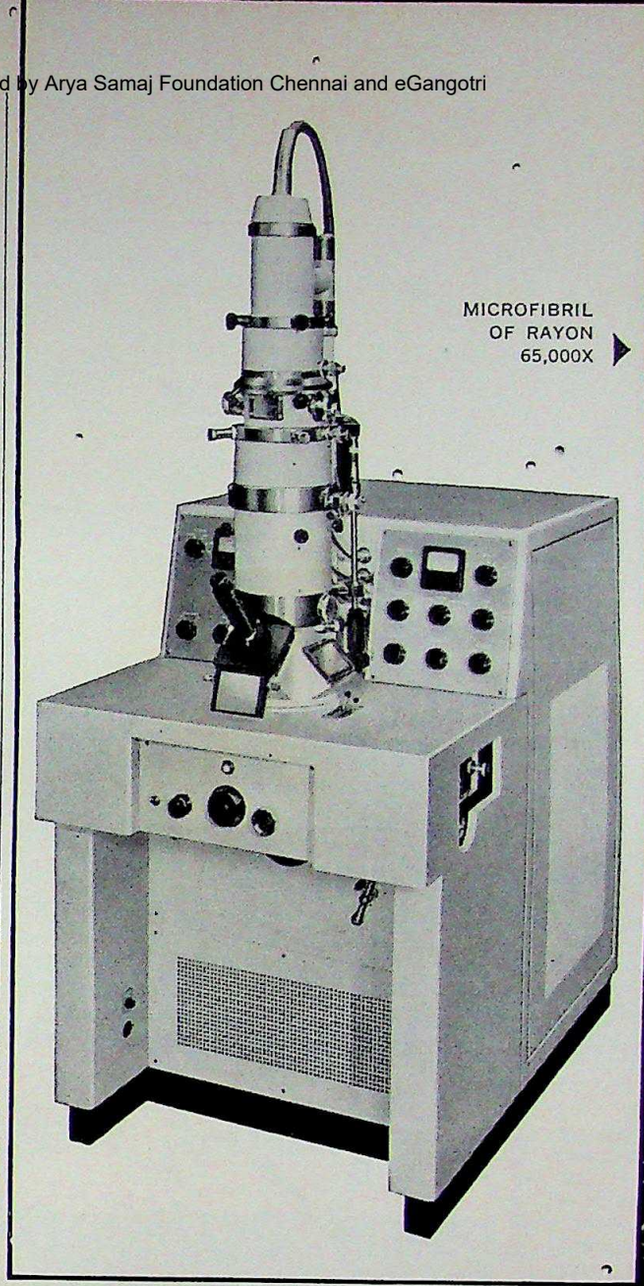
▶ Yellow Springs Instrument Co., Box 106, Yellow Springs, Ohio, announces the release of a new all solid state proportional controller, the YSI Model 72. The Model 72 has direct digital dialing of set point which is settable and resettable to ±0.01°C. Short-term stability is ±0.005°C and long-term stability is ±0:01°C. The proportioning band is adjustable from 0.1 to 3°C to allow optimization of the controller response to the control situation.

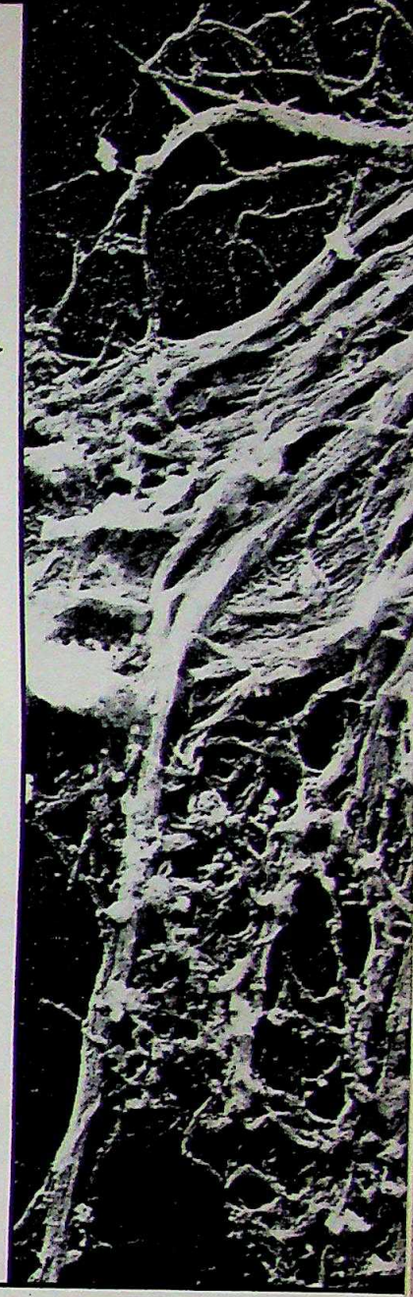
▶ Representing the most modern, precision Wheatstone Bridge available today, Leeds & Northrup's all-new #4289 D-C Wheatstone Bridge offers convenient, on-the-spot measurement of resistance in research, design, and quality control applications, with laboratory accuracy. For complete information, write Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pennsylvania.

▶ Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Illinois, has introduced three new single pan analytical balances for both routine laboratory and high-accuracy analytical weighing. The new balances have capacities of 160 and 200 g with sensitivities of 1.0 and 0.1 mg.

▶ *Bulletin CA-1* of Kontes Glass Co., 126 Spruce St., Vineland, New Jersey, describes the Chromaflex Chromatographic Columns with removable fritted

(*Continued on page A960*)





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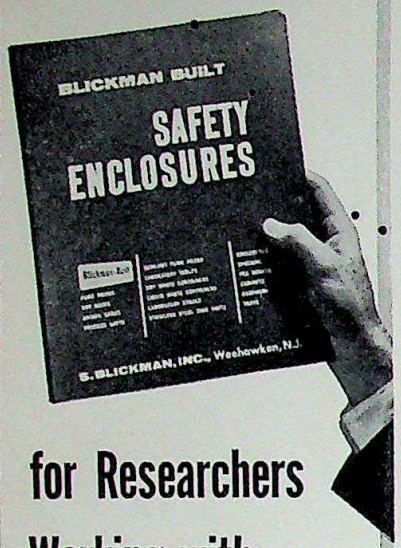
Valuable Reference



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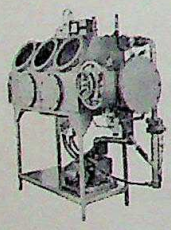

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Out of the EDITOR'S BASKET

disks, extendable lengths, "Teflon" stopcocks, removable reservoirs and "O" ring joints.

▶ For complete information and descriptive literature on the Sievert Welding Torch for plastics, write Nalgene Piping Systems, 75 Panorama Creek Dr., Rochester, New York, 14625.

▶ Soft X-ray measurements originating from the K and L shells of low atomic number nuclides are summarized in a set of data sheets and actual graphs offered by Nuclear Measurements Corp., 2460 N. Arlington, Indianapolis, Indiana, 46-218. The measurements illustrate a new simple technique of producing and measuring these soft X-rays. The results, presented on graphs calibrated directly in KEV, were produced by the Model GSS-1B gamma analyzer.

▶ Carle Instruments, 532 S. Rose St., Anaheim, California, announced availability of a new Micro-Thermal Conductivity Detector System for use in small column gas chromatography. Consisting of a detector block and a separate control unit, the new detector system can be installed easily in any commercial or laboratory-assembled gas chromatograph.

▶ The newest member of the DigiTec family of instruments is the low cost Model "900" AC-DC Converter, featuring 0.3% accuracy for AC inputs up to 500 V, covering a frequency range of 50 CPS to 25 KC. This new instrument has 4 ranges: 1–10–100 and 1000 V full scale, with input impendance of 1 Meg + 47 pf. Its output impendance is 10 K with a 1-sec reading time reponse. Write United Systems Corp., 918 Woodley Rd., Dayton 3, Ohio, for details.

▶ Laboratory Plasticware Fabricators, 615 Wyandotte, Box 213, Kansas City, Missouri, offers color coded Teflon Coated "Spinbars."

▶ A convenient means of handling Dewar flasks safely and quickly in laboratory assemblies is offered by The S/P VacRac. It consists of a nylon fiberglas plate with built-in support rod and stainless steel hinge. At push of a lever, plate swings down, out of way. Distributed by Scientific Products, 1210 Leon Pl., Evanston, Illinois.

New Literature

● Matronic Instrument Co., P.O. Box 304, Newark, Delaware, offers descriptive sheets on their XF-100 gas chromatography filter trap and a column packer, the XL-300.

(*Continued on page A962*)

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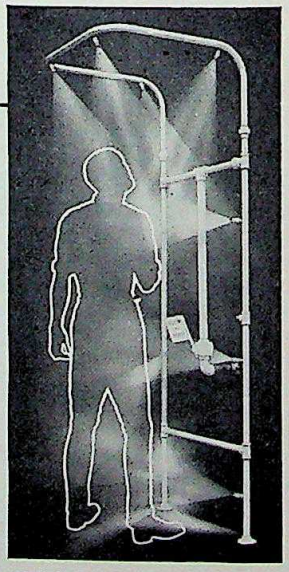

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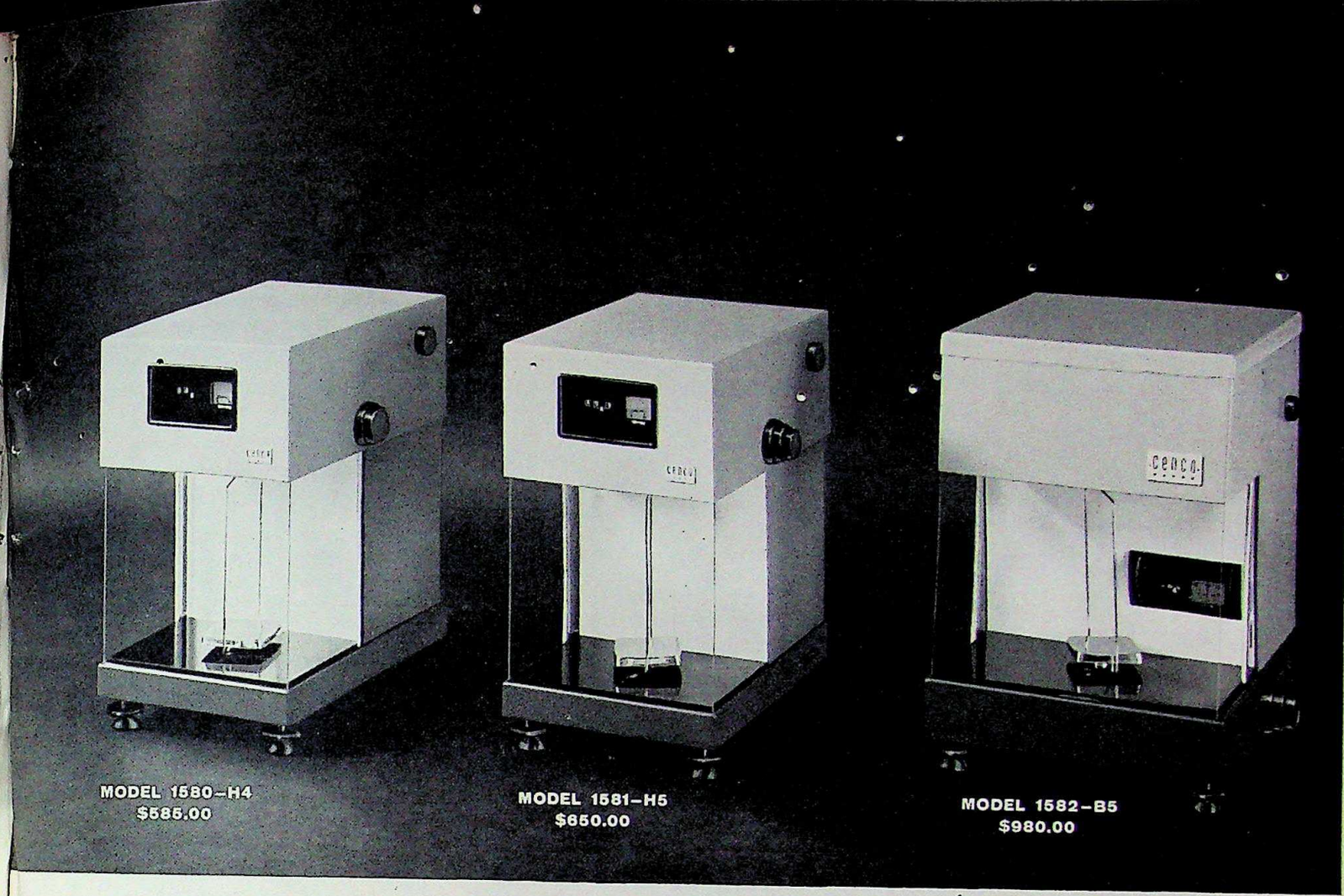

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A. SOLID TITANIUM BEAM / JEWELED MECHANISM: beam surfaces can't flake—lose weight—as do plated beams. Synthetic ruby knife on synthetic sapphire plane, jeweled bearings at all critical points for long-term accuracy. **B. POSITIVE, CHAIN-DRIVEN WEIGHT CONTROL:** stainless steel chain not affected by environment or age, no cord-and-pulley drive to slip. Ring weights are stainless steel, corrosion resistant, non-magnetic, precisely calibrated. NBS Class "S" weights used in models 1581 and 1582; "S-1" in model 1580. **C. ALL-METAL HOUSING:** durable, rugged, minimum dust attraction. Heavy, multiple-coat baked enamel finish. **D. EASY-VIEW WEIGHING CHAMBER:** non-corroding base impervious to chemical attack. Crystal clear glass walls highly resistant to scratching, will not discolor. **E. EFFICIENT, NON-FATIGUING CONTROLS:** simple, speedy operation through natural, straight-line movement of operator's hands from side loading of sample to controls manipulation. With hands off to side, operator always has clear view of readout. **F. EASIER, MORE ACCURATE READOUT:** fixed vernier with cursor for quick, accurate readout.

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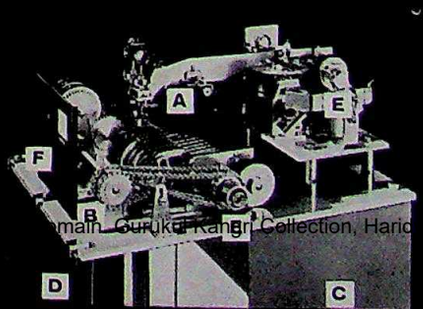

Model No.	1580-H4	1581-H5	1582-B5
Capacity	160g	160g	200g
Sensitivity	1.0mg	0.1mg	0.1mg
Precision	±0.3mg	±0.05mg	±0.03mg
List Price	$585.00	$650.00	$980.00

CENTRAL SCIENTIFIC
a division of Cenco Instruments Corporation
1700 Irving Park Road
Chicago, Illinois, 60613
offices in principal cities

I'd like to know more about Cenco's new single-pan analytical balances, and the introductory 10% discount offer which expires on December 31, 1963.

☐ Please send literature
☐ Please call to arrange a demonstration

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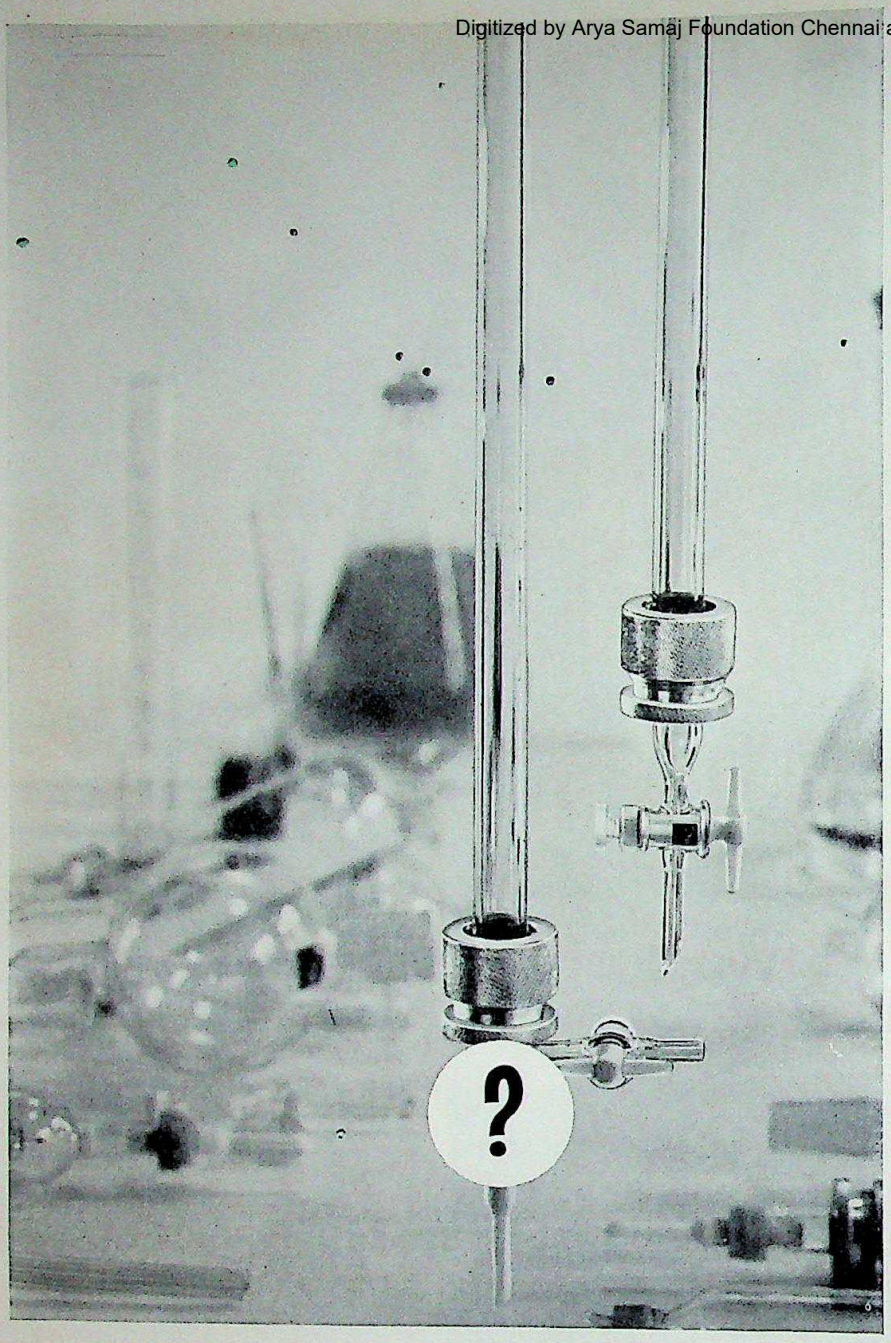

WHAT GOES ON HERE?

If you do any chromatography at all, it should be the new Lab-Crest needle valve, designed especially for your use. It's not a make-do adaptation, but a brand-new design with the precise control and reproducibility you need.

It takes 12 turns of the new valve to get from positive-zero close to unimpeded (3 mm) open—and there's a reference scale on the stem for hairline accuracy.

The valve will never freeze, never need grease. Its body is precision-bore glass tubing; its needle, Teflon.

You can have the valve either by itself or built right into one of our new chromatography-column bottom connections. (The new connections are more than pretty good themselves: minimum volume between the removable fritted disc and the valve keeps the effluent you're working with from remixing.)

All things considered, the built-in's your best bet, but if you just want the valve itself, fine. We'll be glad to oblige. If you'd like information on either the valve, the bottom connections, or both, let us know.

Lab-Crest® SCIENTIFIC DIVISION

FISCHER & PORTER COMPANY, 3423 County Line Road, Warminster, Pa.

Out of the EDITOR'S BASKET

● Ten different bombs for calorimetry and oxygen combustion tests are described in a new 12-page illustrated bulletin (*Parr Specification 1100*). Bombs for both routine and research purposes are covered, including styles for micro combustion, explosive tests, fluorine combustion, and rotating bomb calorimetry, some with platinum liners. Request copies from Parr Instrument Co., 211 Fifty Third St., Moline, Illinois.

● A new Radioassay Electroscope that can be used for tracer studies, radioassays, and for teaching the most basic fundamentals of nuclear science on all school levels, is now available from Atomic Accessories Inc., 811 W. Merrick Rd., Valley Stream, New York. Ask for *Bulletin P-1050*.

● Ace Plastic Co. 91-38 Van Wyck Exp'way, Jamaica 35, New York offers a special bulletin on plastic balls for making crystal lattice, molecular and atomic models. The bulletin lists bulk prices for nineteen diameter sizes ranging from $^1/_8$″ to 2″, connecting rod prices and available colors. Cementing and drilling instructions are also included. Copies of this bulletin are available on request.

● *Catalog No. 2* lists 550 Dictionaries available in 30 languages from Associated Technical Services, Inc., P. O. Box 271-E, East Orange, New Jersey. Price of the catalog is 35¢ (stamps or coins, O.K.)

● The enormous versatility of the Reichert Research Metallograph and Universal Camera Microscope "MeF" is described and illustrated in a 20-page catalogue available from William J. Hacker & Co., Inc., P.O. Box 646, West Caldwell, New Jersey.

● New 4-page brochure describes miniature quartz tube Pen-Ray lamp available with rare gas fills in combinations to meet specialized requirements. The Pen-Ray Lamp is a source of discrete spectral lines, both visible and ultraviolet. Ask for *Pen-Ray Lamp Brochure No. 136*, Ultra-Violet Products, Inc., Dept. PR, San Gabriel, California.

● Copies of the *Keithley Engineering Note*, Summer 1963 edition, are available from the Advertising Dept., Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland, Ohio, 44106.

● Bel-Art Products of Pequannock, New Jersey, announces the publishing of a new supplement to their 1963 catalogue, *Plastics for Science and Industry*.

● A 16-page *1963 Short Form Catalogue* describing the complete Houston Instrument line of X-Y recorders, T-Y recorders, and laboratory test equipment is now

(*Continued on page A964*)

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incorporated... including all facilities, services and stocks of Harshaw Scientific and Chicago Apparatus.

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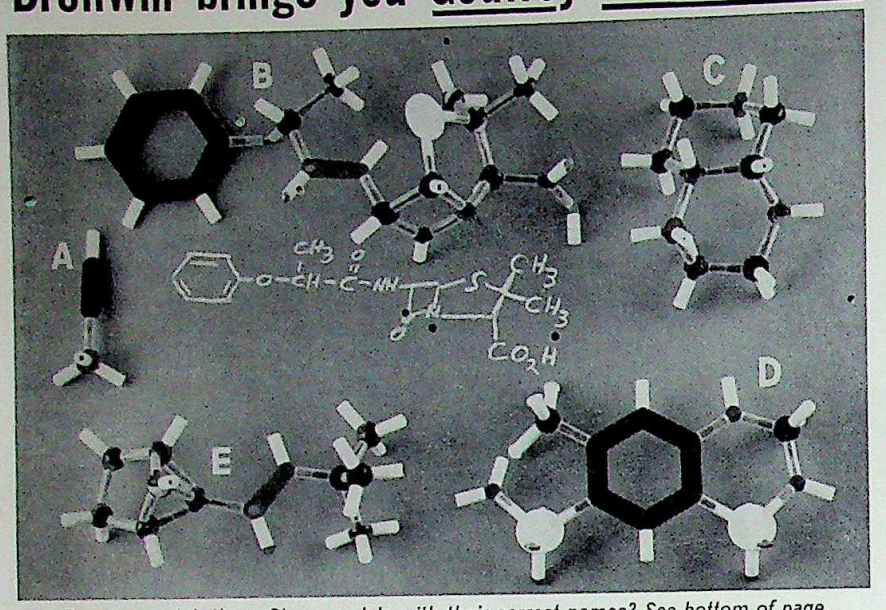
Bronwill brings you Godfrey Stereomodels



Can you match these Stereomodels with their correct names? See bottom of page.

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GODFREY STEREOMODELS are of tremendous importance to teachers, students and research chemists. They present chemical relationships better than ever before possible. You can see skeletal structure . . . how atoms are linked . . . whether they are stable . . . and why. You can even measure internuclear distances with remarkable accuracy . . . a precise, 250,000,000× magnification of all elements is ingeniously maintained (2.5cm = 1Å). Bond angles are correct, too. Elements are all vividly, solidly and permanently colored throughout . . . and virtually unbreakable, too! Free rotation about single bonds is demonstrable . . . yet structures will remain locked in any preset position. Boat or chair conformation of cyclohexane show their natural stability . . . even intermediate twist conformations can be fixed in position for handling and measurement.

The basic kit is supplied, at no extra charge, with a large variety of structural components . . . olefinic and aromatic double bonds, acetylenic triple bonds, the benzene ring, amide and nitrile groups, as well as tetrahedral and trigonal carbon and nitrogen, digonal oxygen and sulfur, hydrogen and the halogens . . . at a price, one-third of any competitive units. No tools are required for any assembly . . . simple, quick, hand connections only. Connector tubes have positive, snap-lock connections, with built-in torsional friction. Large, complex models (synthetic polymers, proteins, polysaccharides) can be assembled and handled without inadvertent disruption.

STEREOMODELS IN TOP PHOTO: A. Methylacetylene; B. α Phenoxyethyl Penicillin; C. *cis* Decalin; D. Bicyclo [2,1,1,0^{5,6}] hexane-5 (N-t-butyl) carboxamide; E. 6-Trifluoromethyl -7-sulfamyl-3,4-dihydro-1,2,4-benzothiadiazine 1,1-dioxide.

It would have been easier if they were visible in their full, identifying colors. Write today for full color brochure.

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Out of the EDITOR'S BASKET

available. For a copy contact Houston Instrument Corp., 4950 Terminal Ave., Bellaire 101, Texas.

● Graphline, Series "S" Recorders, just introduced by Esterline Angus Instrument Co., Inc., P. O. Box 596, Indianapolis 6, Indiana, are described in a 16-page catalogue with a 4-color cover illustration of the compact 8 × 8 in. frontal area panel-mounted instruments.

● A 40-page brochure *Ethyleneimine* giving details on this monomer may be obtained from Chemicals Sales, Literature Section, Dow Chemical Co., Midland, Michigan.

● The introduction of a line of Specific Ion Electrodes for the direct measurement of ion concentrations in solutions was recently announced by the Scientific and Process Instruments Division of Beckman Instruments, Inc., 2500 Harbor Blvd. of Fullerton, California. Ask for *Bulletin 7017*.

● *ph Ranges and Color Changes of Eastman Indicators*, a 12 × 16 in. chart including four new items is available on request from Eastman Kodak Co., 343 State St., Rochester 4, New York.

● A copy of *Bulletin No. 800* describing the new F & M Model 80 Pyrolysis Unit for extending the versatility of gas chromatography is available from F & M Scientific Corp., Avondale, Pennsylvania.

● Corning Glass Works has published a new 360-page illustrated laboratory glass ware catalogue that contains more than 6400 items. The new catalogue lists full technical information and prices on all Pyrex brand, Vycor brand, and Corning brand lab glassware. *LG-3* replaces all previous Corning lab glassware catalogues and their supplements. It is available by request on company or school letterhead from the Laboratory Glassware Dept., Corning Glass Works, Corning, New York.

● A 24-page, 2-color, precision laboratory instrument catalogue is available from RGI Inc., Box #732, Vineland, New Jersey. It features micrometric controlled manometers, McLeod gauges, syringes, burets, vacuum and pressure gauges.

● *Catalogue No. 10*, illustrating and describing the full line of Nevaco high-vacuum pumps, has been issued by Nelson Vacuum Pump Co., 2133 4th St., Berkeley, California, 94710.

● E. H. Sargent and Co. Dept PC, 4647 W. Foster Ave., Chicago, Illinois, 60630, offers a sample of their new 8 1/2 × 11-in. notebook size, two-sided chart of the periodic table.

● Great Lakes Chemical Corp., P.O. Box 472, West Lafayette, Indiana, has

(*Continued on page A966*)

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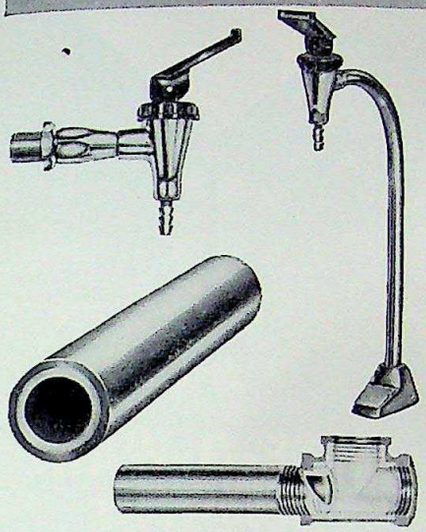
KEEP PURE WATER PURE TO POINT OF USE



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Faucets come complete with accessories for through-wall mounting.

Tin lined pipe is standard weight brass pipe lined with pure block tin 1/16" in thickness. Tin threads on pipe are screwed into tin threads within the fitting to insure tin-to-tin contact. No special tools or skills are needed. No plumbing problems.

NEW BULLETIN #180 describes the complete line of Barnstead tin lined pipe, fittings, faucets and valves. Write for your copy today. Consult Barnstead, Pure Water Specialists since 1878.

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Here's a complete, totally enclosed Distilled Water Center. It is a complete, self-contained package producing higher purity distilled water for all laboratory and research needs. Requires no manual attention. Automatic controls produce and store distilled water around the clock, dispensing it at its own work counter. Maintenance is completely eliminated since the Still never needs cleaning. Needs only 3 feet of wall space. Designed to blend in with Laboratory counters and casework. Ideal for low ceilinged Research and Lab rooms, yet delivers distilled water at working height. No special mountings are needed and installation is easy and inexpensive. The Barnstead "85" has many exclusive operating features including automatic temperature controls and direct reading Purity Meter.

Specifications and information detailed in Bulletin #191. Write for your copy today. No obligation and it will be mailed promptly.

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2. No equipment expense. 30% to 50% lower cost per gallon than with other brands.
3. Hose nipples at both ends for easy connection to faucet and collection vessel with ordinary laboratory tubing.
4. Can be used on closed systems under pressure up to 25 psig. Flow rates, up to twenty gallons per hour.
5. Complete line includes Oxygen Removal, Organic Removal and other special types.
6. No meter or electrical connections needed. Clamps onto Lab stand, or bracket is available for wall mounting.
7. Backed by over 85 years of specialized water purification experience.

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SUSSMAN
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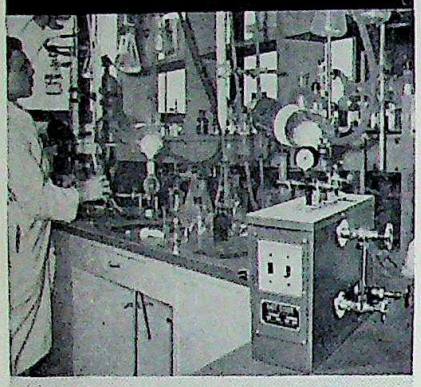

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Additional models available to deliver up to 666 lbs. of steam per hour at pressures through 250 P.S.I. — 407°F.

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published an 8-page, two-color brochure *No. 16337* detailing its product line and listing its customer services. The company produces bromine in its purest form for research, industry, pharmaceuticals, cosmetics, agriculture, and water purification. Thirty-one products are listed.

● Schaar Scientific Co., 7300 W. Montrose Ave., Illinois, 60634, supplier of scientific instruments for 54 years, has announced the publication of their new 1088 page catalogue, *Selected Laboratory Equipment & Chemicals 63/64*. Copies are available on request.

● How do you calculate a satellite's orbit? What color should a satellite be? These questions and others like them are answered in a book titled *Satellite Communications Physics*, prepared by some of the scientists and engineers who designed and developed the Telstar satellite. The 88-page illustrated book is Bell Telephone Laboratories' most recent aid to high-school science education. Teachers and students may obtain copies, without charge, from local Bell telephone companies.

● Exide Industrial Marketing Div., The Electric Storage Battery Co., Rising Sun and Adams Aves., Philadelphia 20, Pennsylvania has issued an illustrated 33-page, two-color manual entitled *The Storage Battery*. The booklet describes the fundamental principles, use and care of lead-acid type storage batteries, illustrates battery construction, explains operating characteristics and reviews maintenance and testing procedures.

New Chemicals

◇ *Catalogue No. 6*, October 1963, lists 16 pages of gas chromatography, thin layer chromatography, and column chromatography supplies and high-purity lipid reference standards. Offered by Applied Science Laboratories, State College, Pennsylvania, 16801, the catalogue includes many new products not listed in earlier editions.

◇ New from Bio-Rad Laboratories, 32nd and Griffin Ave., Richmond, California, is Bio-Gel HT, the first standardized hydroxylapatite (prepared by the method of Tiselius) to be offered commercially. Bio-Gel HT gives the researcher a superior product for the chromatography of proteins, enzymes, and other macromolecules. Ask for *Bulletin 1002A*.

◇ Twenty-nine new ultrapure Eastman Organic Chemicals intended for use as purity-reference Standards or in chemical reactions where small amounts of foreign substances cannot be tolerated are available from Distillation Products Industries, a division of Eastman Kodak Co., Rochester 4, New York. The new line of

(Continued on page A968)

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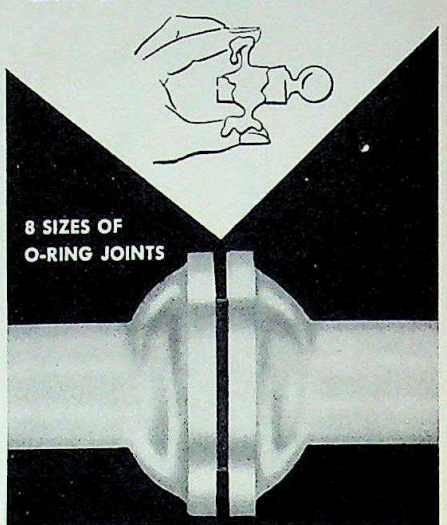
NO GREASE



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MICRO-GLASS LAB WARE OFFERS MANY FEATURES
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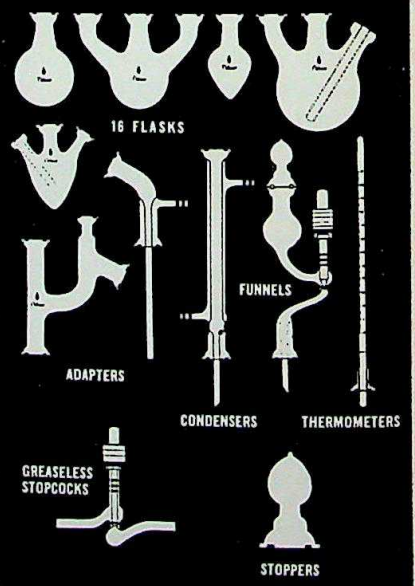
...plus a BIG LINE for versatility



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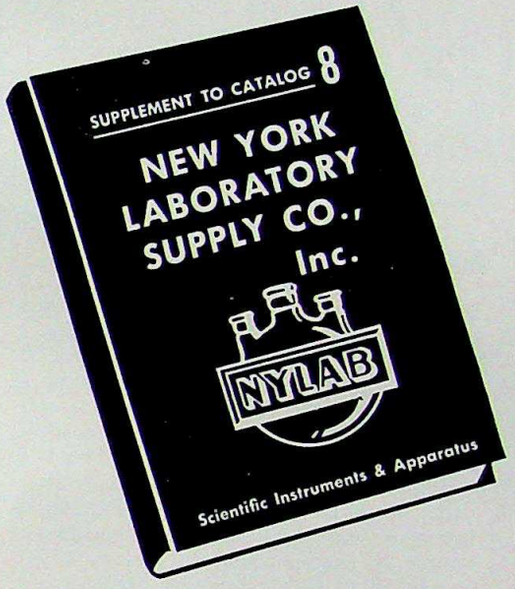

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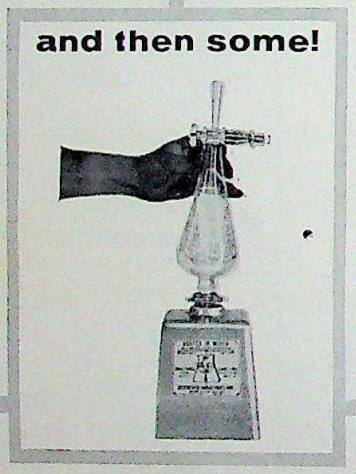

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Out of the EDITOR'S BASKET

chemicals is identified by the letter prefix "G" which identifies the means of final purification: gas chromatography.

◇ The Radiochemical Division of Nuclear-Chicago Corp., 359 E. Howard Ave., Des Plaines, Illinois, announces the availability of Uridine-5-T with a specific activity of 13 curies/mM. The highest specific activity previously available was 3 curies/mM.

◇ Lachat Chemicals, Inc., 10540 Southwestern Ave., Chicago 43, Illinois, offers *Supplement No. 1* to their regular catalogue of products and materials for research. These include column packing for chromatography, non-aqueous solvents for potentiometric titrations and new chemical standards.

Miscellany

★ A scientific recruiting service, believed to be the first of its kind in the country, has been formed in Minneapolis, specifically designed to help industry and business overcome the perennial problem of finding qualified personnel to fill specialized technical positions. Called Dyna-Search Control, Inc., the company is using modern communications facilities in conjunction with a high-speed computer system to compile, analyze, and rapidly supply requesting companies with data on available specialists in virtually all technical areas. Dyna-Search's facilities include a Control Data 160A computer system and the Bell Telephone System's new Model 35 automatic send-receive teletypewriter which, in addition to hard copy, produces eight-level punched tape, compatible with computerized operations. The company has developed a special translation system which converts an applicant's qualifications into a numerically coded "knowledge pattern," capable of being evaluated by the computer.

★ General Electric recently announced that it has developed a new rapid-charge battery—a sealed, maintenance-free, nickel-cadmium cell—which holds major promise both for space uses and for powering portable tools and appliances. Time required for recharging the new battery is sharply reduced, and the battery itself is lighter than conventional sealed cells. The practical result is that battery-operated equipment now can be designed for almost continuous use—with only brief intervals required to recharge the battery.

★ The Chicago Gas Chromatography Discussion Group will hold its second annual gas chromatography course at Roosevelt University, Chicago, Illinois, on January 28–31, 1964. The course will include laboratory sessions and a textbook as well as lectures. The tuition is $40. Write to Dr. R. E. Dedmon, 1753 West Congress Parkway, Chicago 12, Illinois for additional information.

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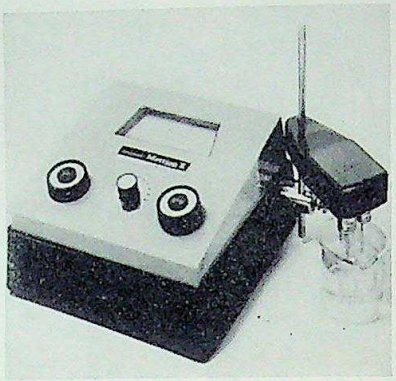

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References

(1) Ind. Eng. Chem. 26–653 (June, 1933)
(2) Ind. Eng. Chem. 25–1112 (Oct., 1933)
(3) National Bureau of Standards Journal of Research 12-241 (Feb. 1934, R.P. No. 649)

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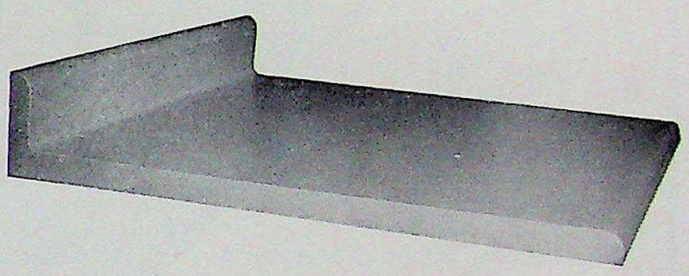

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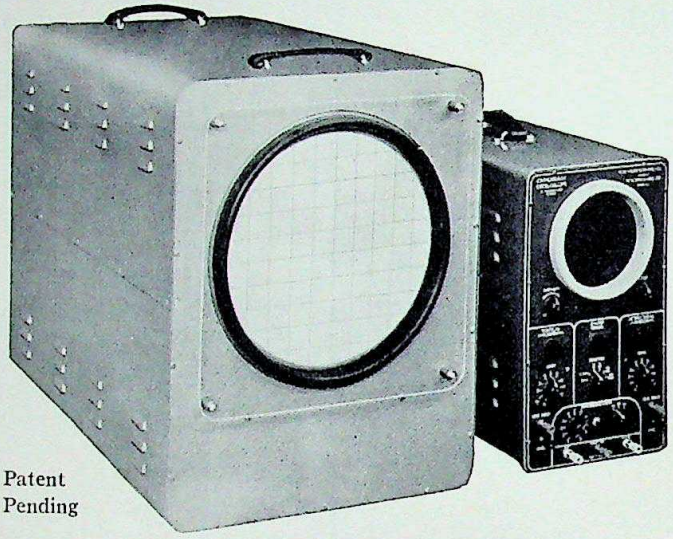

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Chem Ed

EDITORIALLY SPEAKING

Scientific Communication

The Journal of Chemical Education has as its purpose the systematic presentation of chemistry in a coherent, understandable form. With new facts and theories being published faster than anyone can read and assimilate the flood, effective systematization is an indispensable service. It seems appropriate in this connection to raise for reemphasis a few old but very practical questions.

Since English is being ever more widely employed as the language of science, we have additional reasons for improving its effectiveness. Both French and Spanish were reformed in days gone by being made phonetic and by acquiring a simplified spelling. Theodore Roosevelt made a gallant effort to simplify spelling in this country. The net result was a few changes in place names and one more proof that reforming English is like straightening the channel of the Mississippi. One should either leave it to regulate itself or find a way to get concerted action. When I enquired as to whether the ACS Journals might not be strong enough to initiate some spelling reforms, it was pointed out that our journals have problems enough without adding all-out spelling reform. Nevertheless, we ought to go as far as we prudently can to make scientific English shed some of its more archaic forms. Anyway, it is fun to watch the purists wrestle with some of the quaint forms introduced into the mother tongue by some not too skillful translators. To these unhappy purists it should be remarked that imperfect translations are usually much more usable than no translation. In any case we should expand our support for English resumés of foreign language articles and help in every useful way to make English as serviceable as we can as a medium of international communication.

Such thoughts inevitably lead to the ageless question, "Why does anyone tolerate the English system of weights and measures?" There seems to be no logical answer. Presumably no one would seriously argue that the metric system would not be greatly superior. It will be expensive to change over but the price is not apt to get less by waiting. The conclusion to such considerations seems inescapable. We should make the change! A rapid change would probably be cheapest, but as that seems impractical we should at least hurry the inevitable change as much as we can. Dr. Douglas V. Frost in a letter to *C & E News* (October 21, p. 4) makes a strong case for the changeover. Among other things he lists a sizable part of our economy which is already committed to the metric system.

Scientific instruction already uses the metric system. We should likewise use the metric system in instructing college students in engineering. This closer liaison between fundamental science and engineering would at least partly offset the disadvantage of a movement away from industry. One result of this would be that the rising generation of engineers, trained in the metric system, would be alert to opportunities to guide new developments into adopting the better system.

Next, we should start writing engineering specifications in the metric system as well as the English system with a reasonable target date at which time the English system is to be phased out. The government and the more alert segments of industry should take the lead in the changeover with some offering of incentives in cases where the change would cause extraordinary hardship. The change in the writing of specifications need only involve using one or two more decimal points and the actual changes in design could come as dictated by economics. Obsolescence in many industries is such that a changeover in fifteen or twenty years would minimize the economic losses.

Fundamental to the above suggestions and to others such as calendar reform is the underlying fact that all forms of communication are continually undergoing changes which adapt them better to the conveying of information. No one minds this change very much as long as it does not become too conspicuous. However, it is just those procedures which are most used and are therefore most deeply ingrained where simplification and rationalization will be most profitable and where the changes will also be most stubbornly resisted by those who stand to lose by the change. Changes in procedures should be carefully thought through so that as nearly as possible every one profits by the reform, but continual evolution and change cannot be avoided in scientific matters. Research is in fact dedicated to the discovery of useful changes. Ira Remsen and even G. N. Lewis would find a lot of interesting, but to them puzzling, reading in a current number of THIS JOURNAL. This is as it should and must be.

HENRY EYRING
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Herbert M. Clark
Rensselaer Polytechnic Institute
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Criteria for Experiments in Radiochemistry

When Becquerel discovered radioactivity in 1896 (*1*), a new phenomenon was added to those which were then considered to constitute the science of chemistry. Today the various aspects of radioactivity, as they relate to chemistry, are identified with the area of specialty known as radiochemistry. During the first four decades of radiochemistry, radiochemists were concerned mainly with the discovery (*2*), identification, separation, purification and uses of the naturally occurring radioelements (*3*, *4*). A few experiments utilizing the new radioelements as indicators were introduced into college chemistry courses (*5*). Following the discovery of the neutron (*6*) by Chadwick in 1932 and of artificial radioactivity (*7*) by Curie and Joliot in 1934, the scope of radiochemistry expanded to encompass the entire periodic table, as it was then known. Within a few years several hundred radionuclides had been identified and characterized (*8*, *9*). As the number of chemists with experience in the production and, in particular, the utilization (*10*) of radioisotopes grew, the interest in introducing experiments in radiochemistry into chemistry courses in colleges and universities also grew. Apart from photographic film or plates, the instruments available for radioactivity measurements for educational purposes at that time were often limited to various types of electroscopes (*5*, *11–14*). These were and still are (e.g., pocket dosimeters) extremely valuable detectors although limited with respect to sensitivity. Geiger tubes and scalers were in many cases homemade and were nursed along primarily for use in research.

The current era of radiochemistry began about 1939 with the discovery of nuclear fission by Hahn and Strassmann. This was followed in 1940 by the discovery (*15–17*) of elements beyond uranium in the periodic table, namely, neptunium by McMillan and Abelson and plutonium by Seaborg, McMillan, Kennedy, and Wahl. The impact of these discoveries on college chemistry curricula did not begin, however, until after World War II. As a result of the Manhattan Project, there came into being a relatively large community of scientists who were experienced in a wide variety of new techniques and methods of producing, separating, and using radioactive materials. Many scientists returned to academic institutions with interests stemming from their wartime experiences. Declassification of reports began and the facilities of some of the national laboratories became available for the education of college faculty members. Centers for training in radioisotope techniques were established (*18*, *19*). Such wide-scale dissemination of information would not have been effective had there not been a simultaneous improvement in the availability of radioisotopes and instrumentation for radioactivity measurement. Reactor-produced radioisotopes, including fission products, were made available as byproduct material in various forms at a nominal cost. Research reactors and plutonium-beryllium neutron sources capable of inducing radioactivity became available to colleges and universities. Concurrently, the nuclear instrumentation industry grew in magnitude from its small pre-war size to the comparatively large and com-

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Sponsorship of Committee on Nuclear Science—NAS-NRC

The Subcommittee on Radiochemistry is one of a number of subcommittees working under the the Committee on Nuclear Science within the National Academy of Sciences-National Research Council. Its members represent government, industrial, and university laboratories in the areas of nuclear chemistry and radiochemistry.

One of the interests of the Subcommittee is the place of radiochemistry in college and university programs. Previously, a cross-referenced index of published radiochemical teaching experiments was issued as NAS-NRC Publication 905. To further aid the instructor in deciding the value and the feasibility of including radiochemical experiments in his course, the Subcommittee is collaborating with the Journal of Chemical Education in sponsoring publication of a series of new radiochemical experiments. The primary aim of this series is to point out unique advantages of radiochemical experiments for instructional purposes and to furnish to the instructor of inorganic, analytical, physical, organic, and biochemistry a variety of radiochemical experiments for his laboratory program.

We would welcome contributions to this series as well as suggestions and comments from the readers relative to the question of radiochemical instruction, particularly in the undergraduate curriculum. Suggestions and comments should be addressed to Prof. G. R. Choppin (Department of Chemistry, Florida State University, Tallahassee, Florida), who is representing the Subcommittee on Radiochemistry and is coordinating its activities in this area.

N. E. Ballou, *Chairman*
Subcommittee on Radiochemistry

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petitive industry which exists today. To assist in the acquisition of irradiation facilities and nuclear instrumentation for use in college courses in science and engineering, the U. S. Atomic Energy Commission and the National Science Foundation have made equipment grants to educational institutions and have supported the preparation and publication of teaching experiments (*20*).

Several books (*21–31*) containing procedures for experiments in radiochemistry have been published and numerous articles describing specific experiments, the teaching of nuclear chemistry or radiochemistry (*19, 32–42*), or uses of radioisotopes in chemistry (*10, 43–48*) have appeared in THIS JOURNAL. The Subcommittee on Radiochemistry of the Committee on Nuclear Science of the National Academy of Sciences—National Research Council has issued two reports (*49, 50*) relating directly to the teaching of radiochemistry and a series of monographs on the radiochemistry of the elements and on radiochemical techniques (*51*). These monographs contain ideas, methods, and procedures which could be adapted for use in teaching experiments.

Today, then, with an increasing number of college faculty members having some knowledge of and experience with radioisotope techniques, and with instruments, radioisotopes and published experiments being relatively available, the introduction of one or more aspects of radiochemistry into the chemistry curriculum is becoming commonplace. Two distinct ways are used to introduce radiochemistry into the chemistry curriculum. One is by means of a course in radiochemistry. Such a course deals with the more sophisticated methods and techniques described in a number of special laboratory textbooks and is usually taught by a specialist. The second way is by introducing one or more experiments in radiochemistry in some of the regular chemistry courses. It is the latter approach which is given the emphasis in this paper. By drawing attention to certain aspects of experiments in radiochemistry the author hopes to encourage others to design new experiments, modify published experiments, and in a general way extend the usefulness of their nuclear instruments.

The Nature of Radiochemistry

For the sake of discussion, radiochemistry is taken to encompass both the chemistry of radioactive substances and the application of radioisotopic tracer techniques to the study of phenomena associated with the various branches of chemistry. Since radiochemistry is a blend of the classical subdivisions of chemistry, it is not surprising that the techniques of radiochemistry are utilized in connection with the research and teaching activities in these subdivisions, e.g., analytical, bio-, general, inorganic, instrumental, organic, and physical chemistry.

It is important to recognize that radiochemistry differs from stable-isotope chemistry in several ways. For example, since radioactive decay is a non-equilibrium process, time becomes an important experimental variable. In extreme cases the half life may be so short that the radionuclide cannot be isolated and studied radiochemically; or the half life may be so long that the radionuclide, e.g., Th^{232}, can be considered to be "stable" in terms of chemical manipulation.

In radiochemistry it is common to encounter a separation problem involving a mixture of elements having atomic numbers differing by only one or two units. Such mixtures may be produced during the irradiation of a target or may arise from decay of a radionuclide to form a radioactive daughter as in the fission product series or in the naturally occurring series. Although a parent-daughter relationship between radioelements or between isomers of the same element may introduce undesirable radiochemical complications, it may have practical advantages in some cases. Thus, a long-lived parent is often a convenient source of a very short-lived daughter or the radiation emitted by the daughter may enhance the detection and usefulness of the parent radionuclide.

Under suitable conditions the means of detection and measurement of the radiation emitted by a radioactive substance are so sensitive that chemical phenomena may be studied at extremely low concentrations or for extremely small quantities of material. Examples of the uses of radioisotopic tracers are well known. It should be noted, however, that at exceedingly low concentrations, chemical behavior, as observed radiochemically, may differ significantly from that at macro concentrations (*52*).

There are at least two additional ways in which radiochemistry differs from the chemistry of nonradioactive substances. The first is with respect to chemical purity. In terms of the detectable number of atoms of a contaminant, radiochemical purity can be much more stringent than ordinary chemical purity, and the radiochemical purity of a sample may increase or decrease with time. Secondly, the nuclear radiation which provides the basis for the methods of instrumentation used in radiochemistry also creates the problem of radiological; it may, by ionization and excitation processes, induce chemical reactions, e.g., radiolysis, which can complicate the chemical behavior of a sample of radioactive material.

In the design, selection, or evaluation of teaching experiments in radiochemistry several obvious criteria should be considered. The objectives of the experiment should be consistent with the objectives of the course, the experimental techniques required should be consistent with the level of the course and the previous experience of the students, and the experimental procedures must be consistent with safe handling techniques.

It is generally true that the introduction of an experiment or experiments using radioactivity into an established course can be done only by substitution. The difficulty and the justification of such substitution vary with the level and type of course. Although the difficulty may be greatest at the first-year level, an elementary course may be the only chemistry course which a student takes, and it may, therefore, be the course which provides a basis for his understanding of the phenomenon of radioactivity in our nuclear age. This is particularly true in a small liberal arts college. In any case, the introduction of experiments in radiochemistry into the chemistry curriculum should not be based on fashion but rather on recognition of the educational value of such experiments.

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Objectives of Laboratory Experiments in Radiochemistry

Any experiment in radiochemistry provides the student with a laboratory experience in the handling of radioactive material and in the measurement of radioactivity. These are general objectives. In addition, any experiment has one or more specific radiochemical objectives which relate the experiment to a topic or topics in the course. The specific objectives will be used in this paper as a basis for classifying experiments in radiochemistry.

One specific objective, for example, would be to illustrate an aspect or several aspects of the chemistry of radioactive substances, e.g., the preparation, separation, purification, characterization, identification, or assay of radionuclides in various chemical forms. In an experiment having this objective the major emphasis would be on the phenomenon of radioactivity and such an experiment would be introduced on the basis of a belief that radioactivity per se is sufficiently important in the field of chemistry to share in the already crowded schedule. Included in this category would be radiochemical separation of two or more radionuclides followed by an evaluation of the effectiveness of the separation; determination of the half life of a radionuclide by decay measurement or specific activity measurement; characterization of the radiation emitted by a radionuclide; investigation of the properties of the radioelements, including the transuranics (*53*); preparation of carrier-free radionuclides by the Szilard-Chalmers reaction (*54, 55*); and utilization of radioactivity for age determination.[1]

A second specific objective would be to illustrate the use of radioisotopic tracers to provide a more convenient or a more sensitive means for determining the amount or concentration of a substance. Examples of such experiments would be the determination of solubility, common ion effect, and heat of solution (*56–58*); measurement of the distribution between immiscible solvents (*59, 60*); study of chemical reaction rates; evaluation of effectiveness of chemical separation methods (*61, 62*); determination of stability constants for complexes (*63*); radiometric analysis (*64*); activation analysis; study of diffusion; study of adsorption; measurement of surface area; determination of atomic weight, measurement of blood volume (*65*); study of biosynthesis (*66*); etc.

A third specific objective would be to illustrate one or more of the unique applications of isotopes (although not necessarily radioisotopes). Examples of effects which may be measured by the use of isotopes are exchange reactions between different chemical species of an element (e.g., species differing with respect to the oxidation state of a given element) (*67, 68*); exchange reactions between species in different phase states (e.g., a solid salt and its ions in solution) (*69*); certain types of reaction mechanisms, self-diffusion, the isotope effect, and isotope dilution (e.g., isotope dilution analysis). "Tagged-atom" experiments would fall in this category. In general the reaction, process, or effect is studied by measurements which reflect a change in the isotopic ratio of the labeled element.

A fourth specific objective, which is related to the first one, would be to show by an error analysis how the results obtained in the experiment are influenced by the statistical nature of radioactive decay and nuclear radiation detection (*70, 71*). This aspect of radioactivity should receive some attention in any teaching experiment in radiochemistry. The relative importance assigned to it will depend on the background of the students and on how complete an analysis of experimental data is required of the students.

In the foregoing discussion it is implied that an experiment having the second or third objective would be used by an instructor to emphasize the principles involved in the use of radioisotopes in the study of chemical phenomena. To the extent that it is feasible to do so, the radioisotope would probably be selected so that radioactive decay would not complicate the experiment and the radiation measurements would be relatively simple. Although the particular chemical phenomenon would probably be familiar to the student, an objective of the experiment would be to improve the student's understanding of the chemistry involved. On the other hand, the primary educational aim of the instructor might be to introduce a fundamental concept or principle of chemistry more effectively through the use of radioisotopes. A related aim would be to use radioisotopes to effect a saving in teaching time. The appropriate experiments would be similar to those having the second or third objective, but the emphasis would be different. There would be less emphasis on radioisotope methodology.

Finally, there are two areas of chemistry, namely, nuclear chemistry and radiation chemistry, in which the experimental research can involve radioactive materials and can require the use of radiochemical procedures. In some cases, then, a teaching experiment in either of these areas could also be considered an experiment in radiochemistry. For example, a specific objective, which is becoming important as theories of life become more detailed, would be to study the chemical effects of radiations from radioactive material, e.g., radiolysis, Szilard-Chalmers effect, etc. Such experiments in radiation chemistry often require relatively large amounts of activity. When this is the case, they would best be performed as part of a course in radiochemistry, with adequate hazard control equipment and shielding facilities.

Experimental Techniques

The problems of introducing experiments in radiochemistry into a first year chemistry course are certainly different from those encountered for an upper-class course in, for example, instrumental analysis. For the latter, an experiment in radiochemistry may simply provide laboratory experience in one of a wide variety of specialized instrumental methods of analysis. At the first year level, however, one cannot expect the student to follow a procedure requiring sophisticated techniques. The problem is further complicated by the fact that the student may not have had any high school chemistry experience. Furthermore, there is always the possibility that the purpose of the experiment may be obscured by a procedure unnecessarily complex for the level of the course. Simple procedures and techniques are preferable from the point of view of

[1] The paper by Fairhall appearing in this issue, J. Chem. Educ., 40, 626 (1963) illustrates this topic.

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both the student and the instructor. At this level and even through the senior year one is dealing primarily with ideas, concepts, and principles rather than techniques. These should be introduced as simply and directly as possible but without misleading the student by oversimplification. This does not imply that a student should not be required to learn techniques, and it does not overlook the fact that the success of an experiment depends upon the procedure and techniques used. However, the educational value of an experiment is not lost if, for example, a simplified radiochemical separation procedure which takes only 10 min instead of 30 min and requires relatively inexpensive chemical apparatus results in a yield and purity of only 50 and 75%, respectively, instead of 85 and 90%.

There are many ways in which the procedures and techniques for undergraduate radiochemical experiments can be simplified by making use of techniques used for non-radiochemical experiments. For example, it is questionable whether mastery of the technique of using a micropipet and micropipet control is essential in an experiment in an elementary course. Such precision apparatus is properly associated with radiochemistry and its use is not questioned when the success of an experiment depends upon it. It is not sacred, however, and can often be replaced by the humble and more familiar medicine dropper. The latter is far less delicate than a micropipet and is less costly (about $^1/_{100}$ of that for a micropipet plus its control). If desirable, a dropper can be calibrated rapidly in fractions of a milliliter and marked with a file. Furthermore, the tip can be adjusted in a flame to give volumes in the range of 10 to 40 λ drop and, of course, solution concentration can be adjusted for further control. Finally, the placing of a contaminated rubber bulb in a waste storage vessel is less difficult than the decontamination of a pipet control.

A wide variety of other commonly available inexpensive apparatus may also be used effectively in radiochemical experiments. The familiar dropping bottles, test tubes, and centrifuges used for semi-micro qualitative analysis are suitable for experiments involving low levels of radioactivity. Two criteria should be used in the selection of such apparatus. Obviously, the first is that it must be suitable for the proposed chemical manipulation. The second, which narrows down the choice, is that it must be suitable for use in the safe handling of radioactive materials. As a conservative guide in visualizing safety problems it is often helpful to apply the same stringent tests that would be applied to apparatus used for the safe handling of bacteria. This implies that use of the apparatus will not result in the contamination of the student's hands, will not release airborne activity, will not lead to ingestion of activity, will not result in a spreading of activity throughout the working area, and will not result in contamination of the counter. Accordingly, in handling radioactive liquids it is best to avoid tall, top-heavy vessels and vessels having glass stoppers or stopcocks through which leakage is very likely to occur. A simple screw cap vial can often serve as a mixing vessel such as might be used for solvent extraction. A soft metal foil liner (e.g., lead, tin, or aluminum, depending on possible reactions involving the foil) in the cap helps to make a tight seal. Obviously care must be used in venting volatile solvents when a vessel containing a radioactive material is opened.

Pipetting of liquids of any kind by mouth should be strictly forbidden (as should be the case in any chemistry laboratory). Rather inexpensive rubber bulbs can be used with normal size pipets. Radioactive liquids should not be caused to spatter and should not be boiled in open vessels. The latter includes planchets or dishes used for counting. A liquid sample can be evaporated to dryness in a planchet by means of heat lamp which is placed at a distance that is reasonable in terms of the volatility of the liquid. In general, if one avoids handling radionuclides in a volatile or potentially volatile form, there is little need to require a hood for a radiochemical experiment involving a few hundredths of a microcurie of activity. Even with a hood, one would avoid releasing radioactive halogens, volatile radioactive organic compounds, and radioactive gases such as CO_2 and H_2S which might be released by thermal dissociation or acidification of radioisotopically labeled carbonates or sulfides.

Planchets containing radioactive material should be handled with forceps such as the type having medium fine, curved points. The forceps alone should not, however, be used to carry the planchet about the laboratory. To reduce the chance of dropping the planchet, a source holder, i.e., the holder used to position the source beneath an end-window detector, or a small flat plate or tray, should be used to support the planchet when it is being moved.

Consistent with good housekeeping, the laboratory working surface should be kept clean with an easily removed covering of plastic or paper. Inexpensive trays or rectangular glass dishes of the household type are helpful for confining a spill of liquid. All bottles and storage vessels containing radioactive material should be properly labeled in accordance with governmental regulations. This includes, of course, the containers for radioactive liquid waste and for solid waste. Suitable labels, tags, and printed adhesive tape are commercially available from a number of suppliers of laboratory equipment for radiochemistry.

The safe-handling problem varies depending on the chemistry of the experiment, the quantity of radioactivity involved and the particular radionuclide or radionuclides being used. Thus, in separating solids and liquid, centrifugation is generally preferable to filtration because of the greater difficulty in controlling filtration with respect to recovery of material, spread of contamination, etc. Filtration is sometimes unavoidable as, for example, in the preparation of certain sources for counting. Special filtering apparatus (of which several types are commercially available) and careful techniques are required because of the nature of this mechanical separation process.

Quantity of Radioactivity and Choice of Radionuclide

Several factors combine to determine the quantity or radioactivity used in a teaching experiment. Although millicurie quantities of a radionuclide might be available as material produced locally with an accelerator or a research reactor, or as licensed by-product material, or as naturally occurring material, the quantity

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handled by a student in a teaching experiment should be limited by radiological safety requirements to the minimum necessary to obtain meaningful results. Neither an experiment requiring the use of an exceptionally hazardous radionuclide nor one for which the minimum quantity is of the order of a millicurie would be an attractive experiment in a regular undergraduate chemistry course. In the case of radionuclides produced with a small (α,n) source or available as "generally-licensed" or "exempt" quantities of byproduct material, the limitation in quantity used is often controlled by the limited supply. Generally-licensed quantities, commonly limited to a few microcuries, do not require a specific license. They are specified by law and are under the regulation of either the federal or the state government, depending upon the state. Generally-licensed quantities together with the half life and information about the radiation emitted by each radio-nuclide are listed in Table 1. A number of these radionuclides are available in generally-licensed quantities from commercial suppliers[2] as indicated in Table 1. It should be noted that the use of generally-licensed quantities does not entitle one to ignore the practices of safe handling.

[2] A list of suppliers may be obtained from the U. S. Atomic Energy Commission, Division of Isotopes Development, Washington 25, D. C. Most of the companies that sell the instruments and laboratory equipment used for work with radioactive materials also sell the radioisotopes. In addition, there are companies that specialize in radiochemicals. Suppliers are also listed in "The Isotope Index," published by the Scientific Equipment Co., P. O. Box 19086, Indianpolis 19, Ind.

Table 1. Generally-Licensed or Exempt Quantities of Radionuclides[a,b]

Radionuclide	Quantity, μc	$t_{1/2}$	β^c	γ^g
Sb^{124}	1	60.9d	0.61	γ
			2.32	
As^{76}	10	26.8h	2.41	γ
			2.96	
As^{77}	10	38.7h	0.70	(γ)
Ba^{140}	1, as Ba-La^{140}	12.8d	0.48	γ
			1.02	
(La^{140}		40.3h	1.32	γ)
Be^{7}	50	53.6d	...	γ
Cd^{109} [h]	10, as Cd-Ag^{109m}	470d	...	...
(Ag^{109m}		39.2s	...	(γ))
Ca^{45} [h]	10	165d	0.254	...
C^{14} [h]	50	5770y	0.155	...
Ce^{144} [h]	1, as Ce-Pr^{144}	285d	0.3	γ
(Pr^{144}		17.5m	2.97	(γ))
Cs^{137} [h]	1, as Cs^{137}-Ba^{137m}	27y	0.51	...
(Ba^{137m}		2.6m	...	γ)
Cl^{36} [h]	1	3.08×10^5y	0.71	...
Cr^{51} [h]	50	27.8d	...	γ
Co^{60} [h]	1	5.24y	0.31	γ
Cu^{64}	50	12.8h	0.57	(γ)
Eu^{154}	1	16y	0.55	γ
			0.25	
F^{18} [d]	50	112m	0.65	...
Ga^{72}	10	14.1h	0.6	γ
			0.9	
Ge^{71}	50	11.4d	...	Ga-X
Au^{198} [h]	10	2.70d	0.97	γ
Au^{199}	10	3.14d	0.25	γ
			0.30	
H^{3} [h]	250	12.46y	0.018	...
In^{114m}	1, as In^{114m}-In^{114}	50.0d	...	γ
(In^{114}		72s	1.98	γ
I^{131} [h]	10	8.0d	0.61	γ
Ir^{192}	10	74.2d	0.54	γ
			0.67	
Fe^{55}	50	2.94y	...	Mn-X
Fe^{59} [h]	1	44.3d	0.27	γ
			0.46	
La^{140}	10	40.3h	1.32	γ
Mn^{52} [d]	1	5.60d	0.58	γ
Mn^{56}	50	2.58h	2.81	γ
Mo^{99}	10	67.0h	1.23	γ
Ni^{59}	1	8×10^4y	...	Co-X
Ni^{63} [h]	1	125y	0.067	...
Nb^{95}	10	35.0d	0.160	γ
Pd^{109}	10	13.6h	0.96	γ
Pd^{103}	50, as Pd^{103}-Rh^{103m}	17.0d	...	(γ)
(Rh^{103m}		57m	...	(γ))
P^{32} [h]	10	14.3d	1.70	...
Po^{210} [e]	0.1	138d	...	...
K^{42}	10	12.46h	3.58	γ
Pr^{143}	10	13.7d	0.93	...
Pm^{147} [h]	10	2.50y	0.223	...
Ra^{226} [e, f]	0.1	1622y	...	γ
Re^{186}	10	88.9h	1.06	γ
Rh^{105}	10	36.5h	0.57	(γ)
Rb^{86}	10	18.68d	1.82	(γ)
Ru^{106} [h]	1, as Ru-Rh^{106}	371d	0.039	...
(Rh^{106}		30s	3.53	γ)
Sm^{153}	10	46.8h	0.685	γ
Sc^{46}	1	84.2d	0.36	γ
Ag^{105}	1	40d	...	γ
Ag^{111}	10	7.6d	1.04	(γ)
Na^{22} [d,h]	10	2.58y	0.54	γ
Na^{24} [h]	10	15.05h	1.39	γ
Sr^{89} [h]	1	50.5d	1.463	...
Sr^{90} [h]	0.1, as Sr-Y^{90}	28y	0.61	...
(Y^{90}		64.4h	2.18	...)
S^{35} [h]	50	89.0d	0.167	...
Ta^{182}	10	115.1d	0.525	γ
Tc^{95}	1	4.20d	...	γ
Tc^{99}	1	2.12×10^5y	0.29	...
Te^{127}	10	9.4h	0.70	(γ)
Te^{129m}	1	33.5d	1.5	γ
Tl^{204} [h]	50	3.57y	0.765	...
Sn^{113} [h]	10	119d	...	γ
W^{185}	10	75.8d	0.428	...
V^{48} [d]	1	16.0d	0.69	γ
Y^{90}	1	64.4h	2.18	...
Y^{91}	1	59.1d	1.54	(γ)
Zn^{65} [d,h]	10	246.4d	(0.325)	γ
All other β, γ emitting material: 1 μc[i]				
Alpha emitting material: 0.1 μc				

[a] Not as a sealed source.

[b] For byproduct material, based on the Federal Register Title 10, Chapter 1, Part 30 (October 17, 1957) and the New York State Sanitary Code Chapter 1, Part 16 (October 15, 1962). No person is allowed at any one time to transfer, receive, possess or use more than a total of ten generally-licensed quantities.

[c] E_{max} in Mev for only the predominant beta radiation—of interest in selecting a counting procedure. A number in parenthesis indicates low intensity. Negatron emitters unless otherwise indicated.

[d] β^+ emitter.

[e] α emitter.

[f] Radionuclide listed in the New York Sanitary code but not in the Federal Register.

[g] γ indicates emission of γ rays; (γ) indicates low intensity. Characteristic X-rays are indicated when electron capture is not accompanied by γ emission.

[h] Radionuclide is one of those readily available commercially; often sold as part of a set or source kit of generally-licensed material.

[i] Examples of other radionuclides available as generally-licensed, 1 μc quantities are Sb^{125}, Ba^{133}, Co^{57}, Mn^{54}, Hg^{203}, Ag^{110m}, and Sr^{85}. Pb^{210} (a source of Bi^{210} and Po^{210}) is available in 5 μc quantities.

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When there are several radionuclides suitable for use in an experiment, it is advantageous to choose one with a half life not over a few weeks. The apparatus becomes self-decontaminated in a reasonable length of time and the accumulation of radioactive waste does not become a problem. If needed, however, radioactive waste disposal service is available commercially and it is usually feasible to cooperate with other users of radioactivity on campus in employing such service.

For experiments illustrating a method of radiochemical separation, the generally-licensed quantities are usually adequate. There are also several naturally occurring radionuclides which are suitable. One might use perhaps 1–5 times as much as is needed for counting, i.e., a total of about 0.03μc, to obtain a final counting rate of about 1000 cpm. If a radiochemical separation is to be followed by half life determination in the same laboratory period, the time required for the separation and subsequent source preparation must be short. Commonly, but not necessarily, this means a separation by precipitation or solvent extraction. Separation by ion exchange can be rapid when volumes are small. Ion exchange, adsorption, solvent extraction, electrolysis, or precipitation have all been used in experiments involving the separation of a short-lived daughter from its long-lived parent, e.g., UX_1 from U^{238} (*12, 14, 44, 72–75*); UX_2 from UX_1 (*72, 74, 75*); Ba^{137m} from Cs^{137} (*76, 77*); Pb^{207m} from Bi^{207} (*78*); ThB from ThX (*79, 80*); ThC from ThB (*79*); La^{140} from Ba^{140} (*81*); Pr^{144} from Ce^{144} (*82*); and RaE and RaF from RaD (*83, 84*). Thin layer chromatography and filter paper chromatography (*83–85*) are worthy of serious consideration in experiments illustrating radiochemical separation. Although filter paper chromatography, for example is relatively slow, an adequate separation of two radionuclides can often be obtained in less than an hour if ΔR_f for the elements involved is large. Chromatographic methods are inherently simple, and since they require no attention, the students can be conducting other experimental work concurrently. The chromatogram can be sectioned for counting or it can be scanned with an end-window detector (or a cylindrical detector if the radiation is sufficiently penetrating). A simple scanner can be made with a ruler, a scanning slit (e.g., 2 mm) cut in a piece of metal such as lead and interposed between the chromatogram and the detector, adhesive tape, a piece of wood or heavy cardboard, a laboratory clamp with holder, and a ringstand.

Relatively few of those generally-licensed radionuclides which are currently readily available are suitable for the determination of a half life by decay during a single 3-hr laboratory period. In general the activity should be followed for at least two half lives for a sample known to contain only a single radionuclide. For a sample containing long-lived activity as well as the short-lived one to be measured, the decay should be followed until the longer-lived component or components predominate. Allowing for time to prepare a source for counting, the upper limit of half life for measurement during a single 3-hr laboratory period is about 1 hr. The lower limit, assuming a relatively simple counter consisting of a Geiger tube in combination with a scaler or a ratemeter, is about 1 min. Both generally-licensed and naturally occurring radionuclides require radiochemical separation of the desired short-lived nuclide from a long-lived parent.

When an accelerator, nuclear reactor, sub-critical assembly, or (α,n) source is available, several radionuclides suitable for half-life determination can be produced. An (α,n) source, e.g., Pu-Be or Ra-Be (*86*), is convenient for the production of a limited number of radionuclides for low level work. By judicious choice of target material, one can often use the induced activity without radiochemical separation. A selected list of short-lived radionuclides, including two which are naturally occurring, is given in Table 2. This list is limited to those radionuclides for which there is no special problem in readily obtaining target materials or long-lived precursors. Vorres (*87*) has given a detailed description of neutron activation with a Pu-Be source and has listed the initial activities attainable for a number of radionuclides.

Table 2. Selected Beta and Beta-Gamma Emitters with Half Lives Between 1 Min. and 1 Hr.

Radionuclide	Half life (min)	Method of production
Pa^{234} (UX_2)	1.18	Nat.; sepn. from Th^{234} (UX_1)
Al^{28}	2.27	Al(n,γ), Al(d,p), Mg(α,p)
Ag^{108}	2.3	Ag(n,γ), Ag(d,p), Pd(p,n)
Ba^{137m} [a]	2.60	F.P.; sepn. from Cs^{137}; Ba(n,γ)
Cu^{66}	5.10	Cu(n,γ), Cu(d,p), Zn(n,p)
Mg^{27}	9.45	Mg(n,γ), Mg(d,p)
Pr^{144}	17.5	F.P.; sepn. from Ce^{144}
Br^{80}	17.6	Br(n,γ), Br(d,p), Se(p,n)
C^{11}	20.4	C(n,2n); B(d,n); B(p,n)
I^{128}	24.99	I(n,γ), Te(d,2n), Te(p,n)
Cl^{38}	37.29	Cl(n,γ), Cl(d,p),
In^{116m}	53.93	In(n,γ), In(d,p), Cd(p,n)
Bi^{212}(ThC)	60.5	Nat.; sepn. from Pb^{212} (ThB)

[a] Gamma only

Many applications of radioisotopes which one might like to exemplify in a teaching experiment normally require amounts of radioactivity of the order of a few tenths to several millicuries. Appropriate experiments are to be found in laboratory courses in radiochemistry since it is in such courses that the techniques for handling millicurie amounts are presented. When the level of radioactivity is limited entirely to generally-licensed quantities and when many students are involved, the design of a suitable experiment becomes a challenge. In fact, one must often be prepared to tailor the teaching experiment to fit the radionuclide. In research one tries to avoid this limitation. Consider, for example, the use of radioisotopes in the determination of the solubility of a slightly soluble substance. The advantage of the tracer method for analysis in this case can be readily understood in terms of its sensitivity. An experiment dealing with solubility, ionic equilibrium, the common ion effect, etc. is appropriate in a variety of courses. There is no difficulty in preparing a list of substances which are slightly soluble in a common solvent such as water. Yet, relatively few are attractive for a teaching experiment with generally-licensed quantities. A few simple calculations will show why. One must first estimate the quantity of radioactivity required in order that significant results can be obtained with the counting equipment available.

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In its simplest form, the experiment consists of (1) measurement of the radioactivity concentration of the tracer solution to be used, (2) preparation of a few milligrams of labeled solid of known specific activity usually predetermined by the amount of tracer solution used, (3) equilibration of the labeled solid with a solvent (or solution containing a common ion, for example), and (4) measurement of the radioactivity concentration of an aliquot of the saturated solution. Measurements of the activity of the original tracer solution and of the final saturated solution are made in an identical manner, i.e., as a solid after plating or evaporation of the solvent in a planchet, or as the liquid using a suitable Geiger or scintillation counter.

Taking as an example an unshielded, thin-window Geiger counter having a background counting rate of about 30–50 counts per minute, one finds that counting errors associated with the statistical nature of radioactive decay have a strong influence on the results when measurement times are limited to a few minutes and when the counting rate in excess of background for the sample is much less than 300—500 counts per minute, i.e., about ten times background. If the counting conditions are favorable, i.e., high sensitivity of the counter for the radiation, high energy radiation attenuated to a negligible degree by the window, and negligible self-absorption in the source, then it is feasible to expect an overall detection efficiency of 10–20%. Assuming that the lower limit is more realistic, the sample of saturated solution taken for counting should have at least 3000–5000 disintegrations per min, corresponding to about 0.002 μc. If the volume of liquid in equilibrium with the solid is as small as 10 ml and if a 1 ml sample is taken for counting, the 10 ml of solution would contain about 0.02 μc. If the solubility of the substance is 1 mg per 100 ml of water, for example, the specific activity of the substance must be 0.2 μc per mg. Preparation of a sample of the labeled solid weighing only 25 mg will require 5 μc of activity. The lower the solubility of a substance is, the higher is the specific activity necessary because only a fraction of the total activity in the system is in solution and available for measurement. This is quite apart from any aliquoting involved in sampling the saturated solution. In actual applications of the tracer method, higher counting rates are desirable, and the necessary quantity of radioactive material is used. The solubility of calcium sulfate in water is sufficiently high (300 mg per 100 ml) to make its determination feasible (within the limits of reaching equilibrium, etc. in a three-hour period) with generally-licensed quantities. Similarly, the solubility of lead iodide (40 mg per 100 ml of water) can be measured by the use of I^{131}. Sometimes a solubility-type experiment becomes feasible when a complexing agent is present or when the temperature is somewhat above room temperature. The latter variation, of course, introduces the added complication of requiring a temperature-controlled apparatus.

Starting with an estimate of the amount of radioactivity needed for measurement and following a similar approach based on a knowledge of the chemical phenomenon involved, one can estimate the total amount of activity needed for any type of experiment. For radionuclides emitting low-energy beta radiation, e.g., C^{14}, S^{35}, losses in detection efficiency resulting from self-absorption in the counting source and window absorption must be compensated for by using more activity. In the case of C^{14}, the losses of beta radiation by absorption in a counter window are approximately 23, 40, 55, and 65% for window thicknesses of 1.0, 2.0, 3.0 and 4.0 mg/cm^2, respectively. Tritium, although available as a generally-licensed radionuclide, emits such low-energy radiation that relatively sophisticated techniques and rather special detection instruments are required.

The design of experiments requiring only small quantities of radioactive material has been receiving attention, e.g., (*20, 23, 24, 41, 57, 85*), and progress has been made in this direction. Further effort is needed. As already pointed out, however, the level of radioactivity required is not the only factor which determines the usefulness of an experiment. An experiment requiring only a low-level quantity of radioactivity is not a good experiment for a regular undergraduate chemistry course if it involves procedures, techniques, and apparatus used by a specialist who has a well-equipped radiochemistry laboratory at his disposal. There is need for improvement in this direction. Many of the experiments which have been published over the years can be modified for use with reduced quantities of radioactive material and with simplified radiochemical procedures. In some cases the counting procedure can be improved by counting liquid samples of gamma emitters with a well-type scintillation detector of the type which has become available for teaching purposes.

Other Aspects

The design of an experiment in radiochemistry can be strongly influenced by the way in which the experiment is scheduled in a course. In much of the foregoing discussion it is implied that the experiment is to be completed in a single laboratory period. Such is the case when the apparatus and instruments are used by a different student or team of students each period as in a course involving hundreds of students. When the scheduling permits a student to use the apparatus and instruments for more than one period, certain advantages accrue. Somewhat longer-lived radionuclides (*88*) can be used for half life determinations, filter paper chromatography can be combined with autoradiography, etc.

Despite the limitations of a single three-hour laboratory period, much can be accomplished. At Rensselaer, for example, the students in first year chemistry currently conduct two experiments in a single period. One consists of a rapid separation of Pr^{144} from Ce^{144} followed by a determination of the half life of Pr^{144}. The second consists of a tracer experiment in which Bi^{210} is used in determining the distribution of bismuth between two solvents.

It is difficult to relate the dollar cost to the value of an experiment but the relationship cannot be overlooked. The cost of nuclear instrumentation suitable for basic experiments, e.g., detector with scaler or ratemeter, is rather uniform. Sometimes savings can result from choice of detector. If one is not using a radionuclide such as C^{14} or S^{35}, there is little justification for employing an end-window detector with an especially thin window. These special detectors are more costly and will require replacement more often

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because they are more fragile. Glassware and apparatus normally carried in the stockroom should be used whenever possible. Radiochemistry does not inherently require the use of costly apparatus. Students should be impressed by the function of the equipment, not its elegance.

Demonstration Experiments

Most of the foregoing also applies directly to radiochemical experiments designed for lecture or classroom demonstration. New problems arise, however, because of the limited time available for the demonstration and because of the challenge of conveying the nature and progress of the experiment to the spectator. The second complication becomes severe when there are several hundred students in the lecture hall. Where available, closed circuit television is helpful, of course. In general the requirements are (1) a simple and yet striking illustration of the phenomonon (2) a clearly visible or audible indication of the phenomenon and (3) relatively inexpensive apparatus. The counting equipment which probably comes closest to meeting these requirements consists of a Geiger tube and a ratemeter equipped with a loud speaker. The counting rate can be recorded on the blackboard as a quantitative confirmation of the qualitative audible signal experienced by the students.

In designing a lecture experiment one has the advantage of being able to incorporate techniques consistent with the skill of the lecturer. The classification of experiments previously mentioned still applies. Thus the combination of a radiochemical separation followed by determination of a half-life by decay, e.g., the separation of the element protactinium as Pa^{234} (UX_2) from uranyl nitrate and determination of its half life (1.18 min) has been used by the author. Tracer experiments such as those involving isotope exchange or dynamic equilibrium as for a solid salt in contact with a solution can also be used effectively for lecture demonstration.

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Literature Cited

(1) Garrett, A. B., J. Chem. Educ., 39, 533 (1962).
(2) Weeks, M. E., J. Chem. Educ., 10, 79 (1933).
(3) Silverman, A., J. Chem. Educ., 22, 482 (1945).
(4) Silverman, A., J. Chem. Educ., 25, 303 (1950).
(5) Rosenblum, C., J. Chem. Educ., 11, 622 (1934).
(6) Garrett, A. B., J. Chem. Educ., 39, 638 (1962).
(7) Brescia, F., and Rosenthal, R., J. Chem. Educ., 11, 476 (1934).
(8) Darrow, K. K., J. Chem. Educ., 12, 76 (1935).
(9) Croup, A. H., and Goldblatt, L. A., J. Chem. Educ. 14, 270 (1937).
(10) Timm, J. A., J. Chem. Educ., 20, 54 (1943).
(11) Schlundt, H., Fulton, R. G., and Bruner, F., J. Chem. Educ., 10, 185 (1933).
(12) Scherer, G. A., J. Chem. Educ., 26, 111 (1949).
(13) Garner, C. S., J. Chem. Educ., 26, 542 (1949).
(14) Garner, C. S., J. Chem. Educ., 27, 283 (1950).
(15) Perlman, I., J. Chem. Educ. 25, 273 (1948).
(16) "Symposium on the New Elements," J. Chem. Educ. 36, 2 (1959).
(17) Wallmann, J. C., J. Chem. Educ., 36, 340 (1959).
(18) Overman, R. T., J. Chem. Educ., 28, 2 (1959).
(19) Overman, R. T., Coffey, D. L., and Muse, L. A., J. Chem. Educ., 35, 296 (1958).
(20) "Radioisotope Experiments for the Chemistry Curriculum," Radin, N., editor, U.S.A.E.C. Report TID-6374, 1960; prepared and sold by Nuclear-Chicago Corp., 343 East Howard Ave., Des Plaines, Ill.
(21) Aronoff, S., "Techniques of Radiobiochemistry," Iowa State College Press, Ames, 1956.
(22) Bleuler, E., and Goldsmith, G., "Experimental Nucleonics," Rinehart and Co., New York, 1952.
(23) Chase, G. C., and Rabinowitz, J. L., "Principles of Radioisotope Methodology," 2nd ed., Burgess Publishing Co., Minneapolis, 1962.
(24) Choppin, G., "Experimental Nuclear Chemistry," Prentice-Hall, New York, 1961.
(25) Cook, G. B., and Duncan, J. F., "Modern Radiochemical Practice," Oxford, London, 1962.
(26) Francis, G. E., Mulligan, W., and Wormall, A., "Isotopic Tracers," University of London, 1959.
(27) Hermias, Sister M., and Joecile, Sister M., "Radioactivity Fundamentals," (For High Schools) Holt, Rinehart, and Winston, New York, 1963.
(28) Miner, H. A., Shackleton, R. W., and Watson, F. L., "Teaching with Radioisotopes," U. S. Gov. Printing Office, Washington, 1959.
(29) Overman, R. T., and Clark, H. M., "Radioisotope Techniques," McGraw-Hill, New York, 1960.
(30) Schenberg, S., "Laboratory Experiments with Radioisotopes for High School Science Demonstrations," U. S. Gov. Printing Office, Washington, 1958.
(31) Schweitzer, G. K., and Whitney, I. B., "Radioactive Tracer Techniques," D. Van Nostrand, New York, 1949.
(32) "Symposium on the Teaching of Nuclear Chemistry," J. Chem. Educ. 28, 2 (1951).
(33) Williams, R. R., Jr., and Hamill, W. H., J. Chem. Educ., 29, 332 (1952).
(34) Harley, J. H., J. Chem. Educ., 30, 399 (1953).
(35) Wilkinson, G., Diamond, R. M., and Rochow, E. G., J. Chem. Educ. 31, 474 (1954).
(36) Libby, W. F., J. Chem. Educ., 34, 578 (1957).
(37) West, R., J. Chem. Educ., 34, 7 (1957).
(38) Phillips, D., and Maybury, R. H., J. Chem. Educ., 36, 133 (1959).
(39) "A Collection of Papers From the Journal of Chemical Education Related to Training and Experiments in Radioactivity," reprinted and bound by Nuclear-Chicago Corp., 343 East Howard Ave., Des Plaines, Ill., 1959.
(40) Symposium on Radiochemistry in the Curriculum, J. Chem. Educ., 37, 382 (1960).
(41) Radin, N. S., J. Chem. Educ., 38, 344 (1961).
(42) Garrett, A. B., J. Chem. Educ., 37, 384 (1960).
(43) Wiggin, E. A., J. Chem. Educ., 27, 632 (1950).
(44) Brown, C. A., and Rochow, E. G., J. Chem. Educ., 28, 521 (1951).
(45) Berger, C. M., J. Chem. Educ., 29, 84 (1952).
(46) Aebersold, P. C., and Wiggin, E. A., J. Chem. Educ., 30, 229 (1953).
(47) Robinson, R. H., J. Chem. Educ., 32, 370 (1955).
(48) Semenow, D. A. and Roberts, J. D., J. Chem. Educ., 33, 2 (1956).
(49) "Source Material for Radiochemistry," Nuclear Science Series Report No. 27 (rev. 1), Subcommittee on Radiochemistry, National Academy of Sciences-National Research Council, Washington, 1960.
(50) Choppin, G. R., "A Cross-Referenced Index of Radiochemical Teaching Experiments," Nuclear Science Series Report No. 36, Subcommittee on Radiochemistry, National Academy of Sciences-National Research Council, Washington, 1961.
(51) Monographs on the Radiochemistry of the Elements and on Radiochemical Techniques, Subcommittee on Radiochemistry of the Committee on Nuclear Sciences of the National Academy of Sciences-National Research Council, Available from OTS, U. S. Dept. of Commerce, Washington, D. C.

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(52) Schweitzer, G. K., and Jackson, M., J. Chem. Educ., 29, 513 (1962).
(53) Sheppard, J. C., and Jensen, R. C., J. Chem. Educ., 40, 35 (1963).
(54) Williams, R. R., Jr., Hamill, W. H., and Schuler, R. H., J. Chem. Educ., 26, 210 (1949).
(55) Schuler, R. H., Williams, R. R., Jr., and Hamill, W. H., J. Chem. Educ., 26, 667 (1949).
(56) Bradley, A., and Peterson, H. T., Jr., J. Chem. Educ., 37, 398 (1960).
(57) Roig, E., Rieckehoff, I. G., Russo, C. S., and Curet, J. D., J. Chem. Educ., 38, 350 (1961).
(58) Sheppard, J. C., and Jensen, R. C., J. Chem. Educ., 40, 34 (1963).
(59) Forsberg, H. G., Widell, B., and Erwall, L. G., J. Chem. Educ., 37, 44 (1960).
(60) Sheppard, J. C., and Jensen, R. C., J. Chem. Educ., 40, 33 (1962).
(61) Wilkinson, J. R., Sheleck, E. G., and Sheline, R. K., J. Chem. Educ., 32, 613 (1955).
(62) Mucci, J. F., Speigel, D. E., and Stearns, R. L., J. Chem. Educ., 38, 348 (1961).
(63) Kruger, P., and Schubert, J., J. Chem. Educ., 30, 196 (1953).
(64) Hein, R. E., and McFarland, R. H., J. Chem. Educ., 33, 33 (1956).
(65) Lionetti, F., and Sweet, B. H., J. Chem. Educ., 30, 63 (1953).
(66) Lionetti, F. J., and Pastore, E. J., J. Chem. Educ., 36, 612 (1959).
(67) McCool, W. J., and Hentz, R. K., J. Chem. Educ., 32, 329 (1955).
(68) Hein, R. E., and Clegg, R. E., J. Chem. Educ., 33, 320 (1956).
(69) Blake, R. F., J. Chem. Educ., 33, 354 (1956).
(70) Tomlinson, J. D., J. Chem. Educ., 31, 203 (1954).
(71) Kuyper, A. C., J. Chem. Educ., 36, 128 (1959).
(72) Carswell, D. J., and Lawrance, J. J., J. Chem. Educ., 36, 499 (1959).
(73) Smit, J. van R., J. Chem. Educ., 37, 650 (1960).
(74) Braunstein, J., and Young, R. H., J. Chem. Educ., 38, 31 (1961).
(75) Booth, A. H., J. Chem. Educ., 28, 144 (1951).
(76) Hayes, R. L., and Butler, W. R., Jr., J. Chem. Educ., 37, 590 (1960).
(77) Stearns, R. L., and Mucci, J. F., J. Chem. Educ., 38, 29 (1961).
(78) Jones, W. H., J. Chem. Educ., 34, 406 (1957).
(79) Dillard, C. R., and Morton, L., J. Chem. Educ., 35, 238 (1958).
(80) Morimoto, E. M., and Kahn, M., J. Chem. Educ., 36, 296 (1959).
(81) Kruger, P., and Coryell, C. D., J. Chem. Educ., 32, 280 (1955).
(82) Bradley, A., and Adamowicz, M., J. Chem. Educ., 36, 136 (1959).
(83) Dickey, E. E., J. Chem. Educ., 30, 525 (1953).
(84) Lima, F. W., J. Chem. Educ., 31, 153 (1954).
(85) Towne, J. C., and Gatti, B. M., J. Chem. Educ., 40, 243 (1963).
(86) Hamill, W. H., Williams, R. R., Jr., and Schuler, R. H., J. Chem. Educ., 26, 310 (1949).
(87) Vorres, K. S., J. Chem. Educ., 37, 391 (1960).
(88) Smith, W. T., and Wood, J. H., J. Chem. Educ., 36, 492 (1959).

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Dating of Uranium Minerals by the Specific Radioactivity of Lead

This paper discusses a method for estimating the age of a uranium mineral without recourse to elaborate mass-spectrometric techniques.[1] The method is admittedly a very crude one; however, its purpose is not intended to be an alternative to the more accurate dating methods based on lead isotope ratios. Instead it serves as the basis for a few simple radiochemical manipulations, which are instructive in themselves, and as an illustration of the principle of age determination of a mineral via radioactivity. The required manipulations are fundamental to radiochemistry and at the same time so simple that the outlined experiments are suitable for use at the undergraduate or senior high school level. Only very rudimentary equipment is required, consisting of a Geiger counter, a set of aluminum absorbers, and a few elementary pieces of chemical apparatus. The raw material for the experiment, pitchblende ore, is readily obtainable from mineral specimen supply houses and only a small quantity is required per student. Reagent grade uranyl nitrate, available from a number of chemical supply houses, is the only other special chemical which is needed.

As outlined in detail below, the experiment is carried out in two parts, each of which may be completed in a 4-hour laboratory period. The second part is optional and the teacher may instead provide the students with the information (the counting efficiency of the counter) afforded by doing this part of the experiment. It is suggested that the students work in pairs. In addition to the regular laboratory period it will generally be advantageous if the students can have access to the counting equipment for about 3 to 4 weeks in order to measure periodically the radioactivity in the samples; however, only one measurement can suffice for the first experiment provided it comes at least 5 days after the chemical separation.

The teacher will recognize that in addition to the two experiments outlined below there are other experiments which the student may perform using the same

[1] An experiment developed at the request of the Subcommittee on Radiochemistry of the Committee on Nuclear Science, NAS-NRC, as part of a series illustrating radiochemical techniques and their applications.

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radioactive samples. These include (a) studies of backscattering of β radiation by various thicknesses and various kinds of material, (b) the determination of a decay curve, (c) determination of the complete absorption curve of a sample for an estimation of the range of a given β emitter, (d) separation of Bi^{210} from Pb^{210} by a variety of techniques. The pitchblende ore is a rich source of other radioelements which the student can isolate, for example, radium and polonium, and it can serve as the starting point for other radiochemical experiments.

The dating method has been tested on a few minerals which have been accurately dated by mass-spectrometric techniques.[2] These specimens were furnished through the courtesy of Professor Wallace R. Broecker and Mr. Ian G. Swainbank of the Lamont Geophysical Observatory. Samples of these minerals were given to a class of 12 students in the author's senior-level laboratory course in radiochemistry. The results are tabulated in Table 1. It is seen that rather good agreement between this method and the known age of the minerals was achieved in a few instances, and even in the poorest cases the results are "in the right ball park."

Table I. Results Using Mineral Specimens of Known Age

Student group	Sample no.[a]	Age of mineral (in yrs)	Age, this method (in yrs)
1	K 6	6×10^7	14×10^7[b]
2	K 19	8×10^8	6.9×10^8
3	K105	3.4×10^8	3.8×10^8
4	K105	3.4×10^8	2.9×10^8
5	K120	1.6×10^9	1.7×10^9
6	K120	1.6×10^9	1.2×10^9

[a] Sample designations as given in footnote 2.
[b] This specimen is particularly young and contamination by non-radiogenic lead is relatively severe, amounting to 72% of the lead content. Allowing for this fact, the apparent age which is outained is close to the value to be expected by the present method.

Isolation of Radiogenic Lead and Measurement of Its Beta Activity

Consider a uranium mineral, such as pitchblende (U_3O_8) for example, which at some time, t, in the past has crystallized or otherwise been deposited in solid form. If at the time of deposition a fractionation occurred such that the uranium-bearing mineral was formed free of lead, either "ordinary" lead or lead which had formed prior to t through radioactive decay of uranium, then decay of the uranium subsequent to time t will result in an accumulation of lead in the uranium mineral. Radioactive decay of uranium produces lead through two long sequences of α and β decays. A few key steps in these sequences are as follows:

$$U^{238} \xrightarrow[4\beta\text{'s}]{7\alpha\text{'s}} Pb^{210} \xrightarrow{\beta} Bi^{210} \xrightarrow{\beta} Po^{210} \xrightarrow{\alpha} Pb^{206} \text{ (stable)}$$

$$U^{235} \xrightarrow[4\beta\text{'s}]{7\alpha\text{'s}} Pb^{207} \text{ (stable)}$$

At the present time uranium is made up of 99.28 atom per cent U^{238} and 0.72 atom per cent U^{235}. Because these two isotopes of uranium have different half lives (U^{238} 4.5×10^9 yrs; U^{235} 7.1×10^8 yrs) their relative numbers of atoms change with time. If we consider 100 n uranium atoms now, where n is some unspecified but very large number, then we have 99.28 n atoms of U^{238} and 0.72 n atoms of U^{235}. According to the laws of radioactive decay, t years ago there were $99.28\ n\ e^{\lambda_{238} t}$ atoms of U^{238} and $0.72\ n\ e^{\lambda_{235} t}$ atoms of U^{235}. Here λ refers to the decay constant of the radionuclide in question and is numerically equal to 0.693/half life. Since the total weight of each uranium isotope is proportional to the number of atoms and their atomic weights, the proportionality constant being the reciprocal of Avogadro's number N, we can write

$$\text{Wt } U^{238}(t) = 99.28 \cdot \frac{n}{N} \cdot 238\, e^{\lambda_{238} t} \text{g} \quad (1)$$

$$\text{Wt } U^{235}(t) = 0.72 \cdot \frac{n}{N} \cdot 235\, e^{\lambda_{235} t} \text{g} \quad (2)$$

Evidently the difference between the weights of uranium isotopes at time t given by these expressions and the corresponding weights of uranium isotopes present now, $99.28 \cdot n/N \cdot 238$ g and $0.72 \cdot n/N \cdot 235$ g, respectively, represents the weight of the uranium isotopes which have disintegrated in the intervening t years. Thus

$$\text{Wt } U^{238} \text{ disintegrated} = 99.28 \cdot n/N \cdot 238(e^{\lambda_{238} t} - 1)\text{g} \quad (3)$$

$$\text{Wt } U^{235} \text{ disintegrated} = 0.72 \cdot n/N \cdot 235\,(e^{\lambda_{235} t} - 1)\text{g} \quad (4)$$

According to the decay sequence of the radioactive species, each 238 grams of U^{238} which disintegrate gives 206 grams of Pb^{206}, the remaining mass being that of the α particles which were emitted. Likewise each 235 grams of U^{235} gives 207 grams of Pb^{207}.

Thus we can write for the weight of accumulated lead isotopes in the mineral

$$\text{Wt } Pb^{206} \text{ accumulated} = 99.28 \cdot n/N \cdot 238(e^{\lambda_{238} t} - 1)\frac{206}{238}$$

$$= 99.28 \cdot n/N \cdot 206(e^{\lambda_{238} t} - 1)\text{ g} \quad (5)$$

$$\text{Wt } Pb^{207} \text{ accumulated} = 0.72 \cdot n/N \cdot 235(e^{\lambda_{235} t} - 1)\frac{207}{235}$$

$$= 0.72 \cdot n/N \cdot 207(e^{\lambda_{235} t} - 1)\text{ g} \quad (6)$$

The ratio of equation (5) to equation (6) is seen to be a function of t, and hence the ratio Pb^{206}/Pb^{207} is a sensitive measure of the age of the mineral. However the determination of this ratio requires mass-spectrometric techniques. The present simplified method is based on the *sum* of equations (5) and (6):

$$\text{Total wt Pb accumulated} = \frac{n}{N}\,[99.28 \times 206(e^{\lambda_{238} t} - 1) + 0.72 \times 207(e^{\lambda_{235} t} - 1)]$$

$$= \frac{n}{N}\,[2.05 \times 10^4(e^{\lambda_{238} t} - 1) + 1.49 \times 10^2(e^{\lambda_{235} t} - 1)]\text{g} \quad (7)$$

The weight of accumulated lead in comparison with the weight of uranium remaining in the mineral may be expressed as the ratio:

$$\frac{\text{wt accumulated Pb}}{\text{wt of U remaining}} = \frac{\frac{n}{N}\,[2.05 \times 10^4(e^{\lambda_{238} t} - 1) + 1.49 \times 10^2(e^{\lambda_{235} t} - 1)]}{\frac{n}{N}\,[99.28 \times 238 + 0.72 \times 235]} =$$

$$0.858(e^{\lambda_{238} t} - 1) + 6.26 \times 10^{-3}(e^{\lambda_{235} t} - 1) \quad (8)$$

[2] Eckelmann, W. R., and Kulp, J. L., *Bull. Geol. Soc. Am.*, 68, 1117(1957).

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This ratio is plotted in Figure 1 for various values of the time t. It will be seen from this figure that for minerals less than about 70×10^6 years old the radiogenic lead is less than 1% by weight of the uranium present. Such young minerals are more difficult to date by the present simplified method, requiring somewhat larger samples in order to have sufficient recoverable lead; and the results are more sensitive to traces of non-radiogenic lead in the mineral.

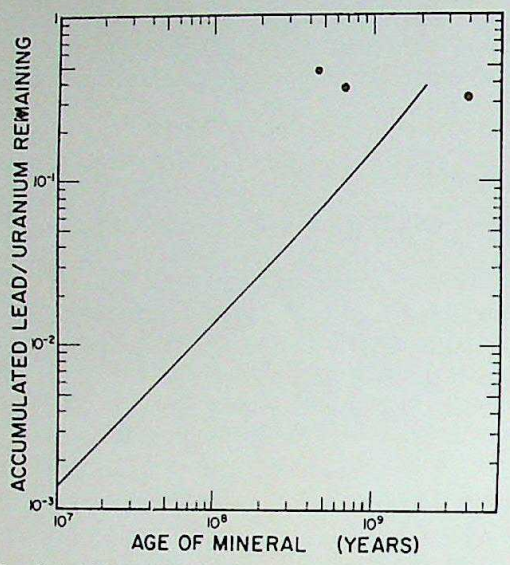

Figure 1. Ratio of the weight of accumulated lead to the weight of uranium remaining as a function of the age of the mineral.

In equation (7) we have neglected the weight of Pb^{210} formed as an intermediate because it is present in exceedingly small amount, by weight. In terms of its radioactivity, however, it gives the same number of disintegrations per unit time as does the U^{238} in the specimen, the reason being that the decay sequence is in a state of secular equilibrium. This means that for each of the species in the sequence the rate of formation is equal to the rate of decay, and a steady state exists.

In the example which we are considering, namely $99.28 \cdot n$ atoms of U^{238} present now, the decay rate of Pb^{210} in the sequence is equal to the decay rate of U^{238}, which in turn is given by

$$\text{decay rate } U^{238} = \lambda_{238} \times 99.28 \cdot n \text{ atoms dis per sec.} \quad (9)$$

This is also the disintegration rate of Bi^{210}, the species formed by decay of Pb^{210}.

Suppose, however, that we now make a chemical separation of lead from the mineral, leaving behind all other elements, radioactive or otherwise. Approximately three hours after the chemical separation, the radioactivity in the purified lead is just that of Pb^{210}.[3] However, the decay of Pb^{210} produces fresh Bi^{210} which soon accumulates in sufficient amount to contribute its own radioactivity to that of the Pb^{210}; after a few weeks the Bi^{210} and Pb^{210} have come into secular equilibrium with each other and both have the same decay rate. The equation which gives the growth of Bi^{210} activity with time is given by the expression

$$\text{d/sec } Bi^{210} = \text{d/sec } Pb^{210}\,(1 - e^{-\lambda_{Bi^{210}} T}) \quad (10)$$

[3] At the time of the chemical separation there is present also 26.8 m Pb^{214}, the antecedent of Pb^{210}. This activity and its immediate decay products soon decay completely to Pb^{210}.

where T refers to time after chemical isolation of lead from the mineral in the laboratory. Therefore the total radioactivity of the lead isolated from the mineral is

$$\begin{aligned} \text{d/sec (total)} &= \text{d/sec } Pb^{210} + \text{d/sec } Pb^{210}(1 - e^{-\lambda_{Bi^{210}} T}) \\ &= \text{d/sec } Pb^{210}(2 - e^{-\lambda_{Bi^{210}} T}) \\ &= \lambda_{238} \times 99.28 \times n(2 - e^{-\lambda_{Bi^{210}} T}) \end{aligned} \quad (11)$$

In both of the expressions (10) and (11) we are considering times T of the order of one month, which is short relative to the half life of Pb^{210} (19.4 yr). That is, for a time short relative to the half life of Pb^{210} the change in the disintegration rate of Pb^{210}, and hence in the equilibrium value of Bi^{210}, is insignificant.

Let us now consider the *specific activity* of the isolated lead fraction. Specific activity is defined as the number of radioactive disintegrations per unit time per unit weight of a substance. In our present example this is given by the ratio of equation (11) to equation (7):

$$\text{Specific activity of lead} = \frac{\lambda_{238} \times 99.28 \times n(2 - e^{-\lambda_{Bi^{210}} T})}{\frac{n}{N}\,[2.05 \times 10^4(e^{\lambda_{238} t} - 1) + 1.49 \times 10^2(e^{\lambda_{235} t} - 1)]}$$

$$= \frac{\lambda_{238} \cdot N \cdot 99.28 \times (2 - e^{-\lambda_{Bi^{210}} T})}{2.05 \times 10^4(e^{\lambda_{238} t} - 1) + 1.49 \times 10^2(e^{\lambda_{238} t} - 1)} \quad \text{d/sec g lead} \quad (12)$$

Note that in this expression the quantity n has cancelled from numerator and denominator. Since this quantity represented essentially the amount of uranium being considered in our example, its cancellation from the equation means that *the specific activity of lead* given by equation (12) *is independent of the amount of uranium under consideration.* It is also independent of the efficiency with which the lead can be recovered from the mineral. The specific activity of lead isolated from a uranium mineral depends only on the time, t, since the mineral was deposited lead-free in nature and the time T following the chemical isolation of lead from the mineral in the laboratory. Curve A of Figure 2 is a graph showing the specific

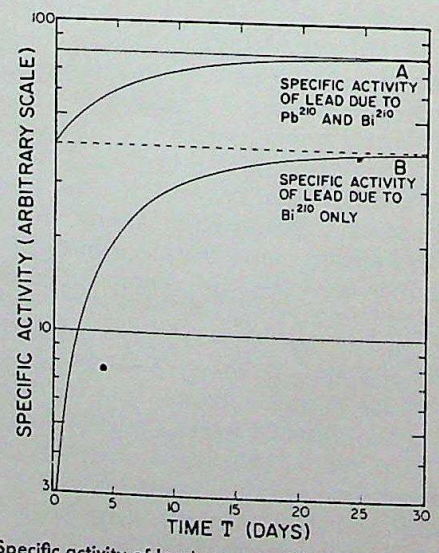

Figure 2. Specific activity of lead separated from a uranium mineral as a function of time after the separation. Curve A refers to the total radioactivity in the lead, curve B to the radioactivity due to Bi^{210} only. Secular equilibrium is attained after about 1 month.

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activity of the lead as a function of T. The secular equilibrium value is reached after about one month.

In practice, the *observable* specific activity of lead isolated from a uranium mineral is due soley to the Bi^{210} daughter of Pb^{210}. The reason is that the radiations emitted by Pb^{210} are so low in energy that essentially none of them penetrate the usual type of detectors used to measure the radioactivity. On the other hand, the radiations of Bi^{210} are sufficiently penetrating that practically all of them are detectable. Therefore, the observed specific activity of purified lead follows curve B in Figure 2 rather than curve A, and at secular equilibrium the observable specific activity is one-half of that given by equation (12):

$$\text{Observed specific activity of lead at equilibrium} = \frac{\lambda^{238} \cdot N \cdot 99.28}{2.05 \times 10^4 (e^{\lambda 238 t} - 1) + 1.49 \times 10^2 (e^{\lambda 235 t} - 1)} \text{ d/sec g lead} \quad (13)$$

The observable specific activity of chemically isolated lead, due only to Bi^{210}, is plotted in Figure 3 as a function of the uranium mineral formation time, t, for various times T after the isolation of lead. By the use of this graph the age of a uranium mineral may be determined by observation of the radioactivity associated with lead isolated from the mineral.

In all of the preceding it has been assumed that the uranium mineral was initially lead-free. If some lead contaminated the uranium mineral when it was formed, then the observed specific activity will be less and the apparent age of the mineral will be older than it otherwise would be if there were no contaminating lead present. A more sophisticated technique involving mass spectrometric analysis of the isolated lead is required for accurate dating of uranium minerals contaminated with ordinary lead. Figure 4 is a graph showing the apparent age versus the true age of a uranium mineral for various proportions by weight of radiogenic lead and contaminating lead in the specimen.

Of course if the mineral incorporated some of its previously-formed radiogenic lead during recrystallization there is no way to determine whether this type of contamination has indeed occurred and an older apparent age will result.

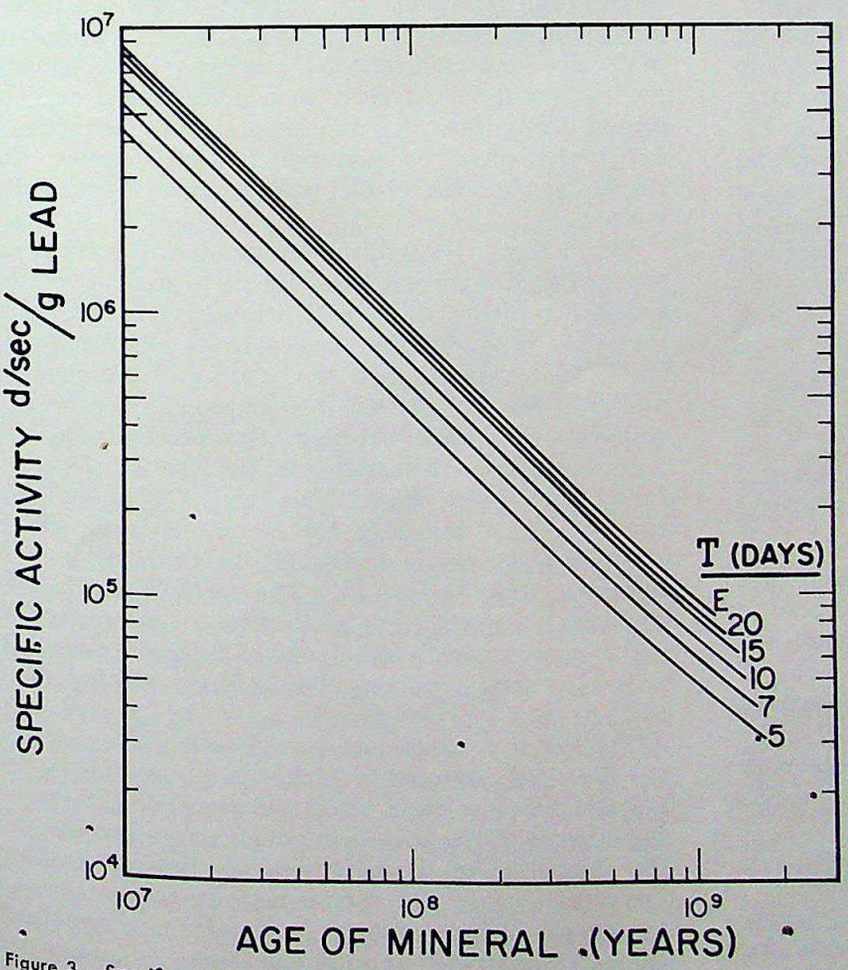

Figure 3. Specific activity of lead isolated from a uranium mineral as a function of the age of the mineral for measurements made at various times T after the time of separation of lead from the mineral.

Experiment Dating Uraninite Minerals

Place a small quantity (about 100 mg) of the mineral in a 15-ml centrifuge tube. Add 10 drops each of conc. HNO_3 and H_2SO_4 and heat to boiling (caution!) over a burner. The U_3O_8 will dissolve readily in this mixture at a rate dependent upon particle size. As the acid boils away replenish with more conc. HNO_3. When most of the mineral appears to have dissolved, evaporate off most of the excess acid, cool, and dilute the mixture to 5 ml with H_2O. Warm the mixture and add 1 drop satd. $Ba(NO_3)_2$ solution (Note 1). Keep the solution hot for a few minutes, then centrifuge the mixture. Decant and discard the aqueous phase. Wash the residue with 2–3 ml of warm H_2O containing a drop of dilute (1:10) H_2SO_4. Centrifuge and discard the washings.

To the residue in the centrifuge tube add 1 ml 6 M NaOH. Disperse the solid with a stirring rod and warm the mixture in a boiling water bath. Dilute to 5 ml with water (stir the mixture) and centrifuge. With an eye dropper pipet transfer the aqueous phase to a clean centrifuge tube.

To the solution add a drop of methyl orange indicator. Acidify the solution by dropwise addition of HNO_3 until the indicator turns from yellow to red (Note 2). Use a stirring rod to mix the solution thoroughly during acidification. Add 1 ml of 0.5 M Na_2SO_4 solution. Warm the solution in a boiling water bath for a few minutes, stirring frequently. Cool under running tap water. Centrifuge the precipitate of $PbSO_4$, discarding the aqueous phase.

Redissolve the precipitate of $PbSO_4$ in 1 ml 6 M NaOH and dilute the solution to 5 ml with water. Stir the solution in the test tube and add 1 drop of 10 mg/ml Fe(III) carrier. Stir vigorously so as to disperse the precipitated $Fe(OH)_3$. Centrifuge the precipitated $Fe(OH)_3$, decanting the solution into a clean centrifuge tube.

Acidify cautiously with HNO_3 using methyl orange indicator in the same manner as before. Add 1 ml of 0.5 M Na_2SO_4 solution. Warm the mixture to coagulate the precipitate of $PbSO_4$. Using a filter-

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stick with chimney arrangement (Note 3), filter the suspension through a 1-in. fine-porosity filter paper which has been previously weighed to 0.1 mg. Wash the precipitate on the paper with water followed by alcohol. Dry the filter paper at 110°C for 10 min. Weigh the dried filter paper after it has stood for 10 min in the atmosphere.

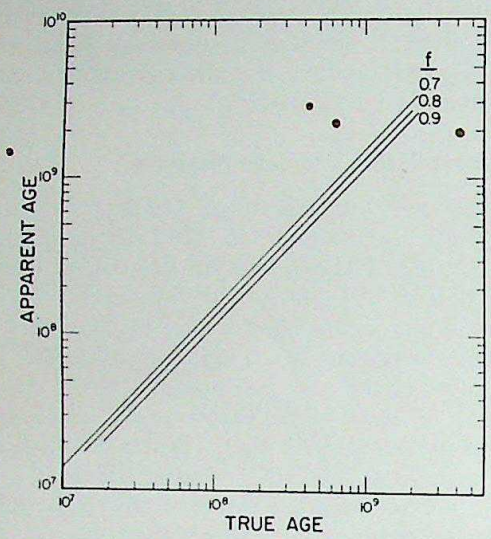

Figure 4. Apparent age versus true age for uranium minerals contaminated with extraneous lead. Curves are given for several fractions, f, of the lead presently in the mineral which was derived from uranium decay since the mineral was formed.

Mount the filter paper for counting, covering the precipitate and filter paper with a thin plastic film. Count the precipitate periodically over a period of about 10 days to establish the growth of Bi^{210} and to enable you to predict the final equilibrium value, A c/s (curve B, Fig. 2) (Note 4).

The counting efficiency of the counter-sample combination must be known. The biggest factor which enters into the counting efficiency is usually the solid angle subtended by the sample and the window of the counter. A simple way to determine this experimentally is given in the second part of this article. If the counting efficiency is known the specific activity of the lead may be calculated from the equation

$$\text{specific activity of lead} = A\ \text{c/s} \times \frac{100}{\text{counting efficiency (\%)}} \times \frac{1.47}{\text{wt}\ PbSO_4\text{(g)}}$$

The factor 1.47 is a gravimetric factor related to the proportion of the $PbSO_4$ precipitate which is Pb. In the present case the atomic weight of the lead is between 206 and 207, depending on the age of the mineral. The uncertainty in the atomic weight of the lead which should be used in this equation makes very little difference to the final result.

The age of the mineral is obtained from the observed specific activity of the lead using the appropriate line in Figure 3.

Notes

1. The barium is added in order to remove traces of radium from the solution by binding it as an insoluble sulfate precipitate. This prevents contamination of the lead sulfate precipitate, recovered in subsequent steps, by radium. The barium sulfate precipitate may also assist in the precipitation of lead sulfate from the solution by isomorphosis substitution of Pb^{++} ions in the $BaSO_4$ lattice.

2. The solution should be only slightly acid; otherwise, excess H_3O^+ ions lower the SO_4^{--} ion concentration by formation of HSO_4^- ions. The solubility of $PbSO_4$ in the solution is then correspondingly increased, resulting in poor efficiency of precipitation of $PbSO_4$ in the next step.

3. This is not a standard item in scientific supply catalogues. The components may be procured from Scientific Glass Apparatus, Inc., Bloomfield, N. J., as follows: the base is made from a Filter Tube (F-3820, 30 mm disc, medium porosity) which has had the rim ground off to make a flat surface. This tube is inserted through a rubber stopper and mounted in a suction flask. The filter chimney ($1.50 each) may be obtained by referring to Print No. 576,141. The filter paper disc, punched from sheets of ordinary filter paper by a 1-in. die punch, is held firmly between the disc of the filter tube and the filter chimney by a #28 clamp (C-5165). The width of the prongs of the clamp has to be increased (with a file) to accommodate the disc and chimney.

4. Alternatively the precipitate may be counted only once, preferably at least 5 days after the chemical separation. The age is calculated using the appropriate line in Figure 3. If the second part of this article is performed also, it is worthwhile to measure a short portion of the absorption curve of Bi^{210} to correct the observed counting rate for absorption of the β rays by the sample, cover, and counter window.

Measurement of the Counting efficiency of a Sample

The observed counting rate, R, of a given sample of radioactive material positioned beneath the window of a counter is related to the disintegration rate of the radioactive species in the sample, A, by the expression

$$R = A \times G \times f_s \times f_a \qquad (14)$$

The factor G in this expression is called the "geometry factor" and represents the fraction of the radiations, emitted isotropically by the sample, which are emitted in the direction of the counter window. Provided they are neither deflected from their initial path nor absorbed along the way this fraction of the emitted radiations would be detected by the counter; the remaining fraction, 1-G, simply miss the counter entirely.

The factor f_s takes into consideration the effect on the observed counting rate due to scattering of the radiations along their path through matter. The materials responsible for the scattering are the sample itself, the sample mount, the housing of the counter, and even the air between the sample and the counter window. Sometimes the scattering process results in a particle being deflected into the counter from an initial path which would have caused it to miss the counter. This increases the counting rate. Sometimes the reverse is true and the counting rate is correspondingly decreased. The factor f_s is difficult to assess accurately, but so long as the sample is thin and mounted with a minimum of material around it, f_s is not very far from, but slightly greater than, unity.

The factor f_a takes into consideration the effect on the observed counting rate due to absorption of the radiations before they reach the sensitive interior of the counter. The materials which are responsible for the absorption of the radiations are the sample itself and any covering film, the air between the sample and the counter window, and the counter window itself. By determining the rate at which the radiations are absorbed by matter, called an absorption curve, it is possible to assess the factor f_a.

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Usually the absorption curve is determined by interposing thin sheets of aluminum foil of known thickness between the sample and the counter window. By plotting the observed counting rate $R(t)$ as a function of the effective *total* thickness of absorber (t) (which is taken to be the sum of the thickness of the counter window, of the added aluminum absorber, of the sample cover, of the air between the sample and the counter window (1.2 mg/cm^2 per cm of air), and one-half the thickness of the sample itself, all thickness being measured by units of mg/cm^2) the data may be extrapolated to zero total absorber. This gives a counting rate $R(o)$ which is corrected for absorption effects so that the factor f_a may be eliminated from equation (14). In effect $R(o)$ is equal to R/f_a.

By measuring the absorption curve of a sample of known disintegration rate A, so as to obtain $R(o)$, the combined factors G and f_s may be obtained simply as

$$G \times f_s = \frac{R(o)}{A} \tag{15}$$

Samples of known disintegration rate may be prepared by evaporation of standard solutions which have been certified to contain a given amount of activity per unit volume. Such standard solutions are available commercially. For our present purposes, however, a suitable standard may be prepared from a uranium stock solution of known concentration. If the uranium solution has been prepared several months prior to its use the U^{238} is in secular equilibrium with its immediate radioactive descendents 24.1d Th^{234} and 1.18 m Pa^{234m} + 6.7 h Pa^{234}. Hence, for a given amount of U^{238}, the disintegration rate of each species is known. These disintegration rates for 100 mg of U^{231} are given in Table 2.

Table 2. Activities Associated with 100 mg U^{238} (Depleted Uranium)

Species	Half life	Dis/sec	Decay characteristics
U^{238}	4.51×10^9 yr	1231.8	4.2 Mev α
Th^{234}	24.10 day	1231.8	0.10 Mev β 35% (γ) 0.19 Mev β 65%
Pa^{234m}	1.18 min	1224.0	2.31 Mev β 90% 1.50 Mev β 9% (γ) 0.58 Mev β 1% (γ)
Pa^{234}	6.66 hr	7.8	1.13 Mev β 13% $\leq$0.53 Mev β 87% (γ)
U^{234}	2.48×10^5 yr	1232	4.8 Mev α

There is a rather trivial point which arises having to do with the concentration of U^{238} in the uranium stock solution used to prepare a standard source. Practically all the uranium available commercially at the present time, for example as inorganic chemical reagents, has had most of the fissionable U^{235} removed from it before it is made available for commercial use. That is, it is nearly 100% U^{238}. Natural uranium, on the other hand, is 99.3% U^{238} and 0.7% U^{235}. For any given sample of a uranium salt there might be some question as to its isotopic composition. For present purposes however, the error introduced by the uncertainty in the exact isotopic composition of the uranium is negligibly small. If the uranium reagent used in making the stock solution has been procured recently,[4] it is probably safe to assume that the secular equilibrium values are as in Table 2.

In order to prepare a standard source of known disintegration rate from the uranium stock solution, it is necessary to separate the thorium and protactinium descendants chemically and with a known efficiency of separation. It is not suitable merely to evaporate an aliquot of the solution because the resulting sample would be very bulky and it would be difficult to assess quantitatively the effects of scattering and absorption of the β radiations. The thorium and protactinium decay products of the uranium are present in the stock solution in exceedingly low concentrations so that it is necessary to employ a carrier to assist their removal from the solution. Thorium element, Th^{232}, would of course be an ideal carrier for Th^{234}, from a chemical point of view, since they are isotopic. However, thorium itself is radioactive with numerous radioactive decay products. Their presence in the counting sample would introduce complications so that thorium is not a suitable carrier for present purposes. There are, however, numerous possibilities for non-isotopic carriers for thorium. One which we shall use is the rare earth lanthanum. Both thorium and the rare earths form insoluble precipitates with F^- ion and OH^- ion. Precipitation of a rare earth ion in the presence of tracer amounts of thorium with either of these ions results in essentially quantitative coseparation of the thorium tracer. Since the thorium tracer comes to radioactive equilibrium with its Pa^{234m} daughter within a few minutes we need not be concerned whether or not protactinium is also co-separated with the rare-earth precipitate.

Apart from the question of the degree of coseparation of tracer Th^{234} with a La precipitate, there is also the matter of the efficiency with which the precipitate can be transferred to the sample mount for counting. By saving the solution and using the same vessels for a second precipitation it is possible to obtain an accurate estimate of the efficiency with which the tracer can be collected and transferred in a single separation. Suppose the collection efficiency is constant in each separation and equal to ϵ. Then the fraction of the total activity collected in the first separation is ϵ; in the second separation the fraction of the total initial activity collected is $(1 - \epsilon)\epsilon$; in the third separation it is $(1 - \epsilon)^2\epsilon$, etc. Provided ϵ is not too far from unity, e.g., >0.9, essentially all of the activity is collected in the first two separations. The efficiency of collection then can be determined by the ratio of the activities observed in the first and second separations:

$$\frac{\text{activity from 1st separation}}{\text{activity from 2nd separation}} = \frac{\epsilon}{(1 - \epsilon)\epsilon} = \frac{1}{1 - \epsilon} \tag{16}$$

In counting a sample of Th^{234} there are principally two β emitters which are detectable: Th^{234} and Pa^{234m} (Pa^{234} may not completely coseparate with Th^{234}, but most of its radiations are eliminated anyway when the absorption curve of the sample is determined). The radiations of Th^{234} are of short range while those of Pa^{234m} are much more penetrating. In order to

[4] Unfortunately, the information given on the label of the bottle is of no use in establishing the isotopic composition of the uranium.

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correct for absorption effects, and to assess the contributions to the observed counting rate by each species, an absorption curve in aluminum is determined out to about 100 mg/cm² of total absorber in increments of 10–15 mg/cm². The absorption curve, plotted on semi-log paper is observed to be flat over most of this range of thicknesses, representing the absorption of the more penetrating Pa^{234m} radiations, except for a slight rise at low total thicknesses (Th^{234} radiations). The flat portion may be extrapolated to zero total absorber to give $R(o)$ of Pa^{234m}. This value may be substituted in equation (15), along with the value of A for Pa^{234m} (Table 2) appropriate to the amount of U^{238} used. In order that the scattering factor f_s for Pa^{234m} be as nearly the same as that of Bi^{210} in the first part of the experiment, the sample of Th^{234}-Pa^{234m} should be mounted in much the same manner as the $PbSO_4$ sample. In measuring an absorption curve the aluminum absorbers should be placed close to the counter window.

The Experiment

The U^{238} stock solution is preferably made up several months in advance of its use in order to ensure that Th^{234} will be in secular equilibrium with its U^{238} parent.

For 500 ml of stock solution containing 50.0 mg U^{238}/ml, weigh out 52.729 g of $UO_2(NO_3)_2 \cdot 6H_2O$ (f.w. 502.23, assuming the uranium is 100% U^{238}). Add this to a 500-ml volumetric flask containing 4 ml of concentrated HNO_3. Fill the flask to the bottom of the neck with distilled water. Swirl the contents to dissolve the salt. Make up the volume to the mark with distilled water. Mix thoroughly, and transfer the stock solution to a clean, dry, glass-stoppered bottle. Lubricate the stopper with silicone stopcock grease. Label the bottle, including a strip of the standard warning label for radioactive materials.

Separation of Th^{234}

Using a safety pipet manipulator (propipet) (no oral pipetting!) remove two 2-ml aliquots of stock solution. Transfer these aliquots to separate, clean 15-ml centrifuge tubes. Label these tubes A and B for later identification. To each centrifuge tube add 1 ml of a 3 mg/ml stock solution of La^{3+}. Dilute the contents of both tubes to 5 ml with water. Add 1 ml of 2 M KF stock solution to each tube and swirl the contents of both to ensure complete mixing of the reagent. Allow the mixtures to stand for about 3 minutes and then centrifuge both tubes (Note 1).

With an eyedropper pipet decant the supernatant solutions from both centrifuge tubes into separate, clean centrifuge tubes. Label these tubes A or B, according to their contents, and set them aside.

Wash the precipitates of LaF_3 with 3 ml of distilled water from a wash bottle. Direct the water in a fine stream at each precipitate so as to break it up. Shake vigorously to disperse the precipitates. Centrifuge the mixtures and decant the washings with an eyedropper pipet. These washings may be discarded.

Dissolve the precipitates of LaF_3 by adding to each 1 ml of saturated H_3BO_3 solution and 2 drops of conc. HNO_3. Warm the mixture to hasten the dissolution. When the precipitates have disolved dilute the solutions to 5 ml with water. Make each solution basic by dropwise addition of conc. NH_4OH solution. (Precipitation of flocculent $La(OH)_3$ indicates when the solution is basic.) Swirl the contents of the tubes to ensure complete mixing of the reagent. Centrifuge the mixtures and decant the supernatant solutions, which may be discarded.

Add 10 drops of 1 M HCl to each centrifuge tube, allowing the acid to wash down the sides of the centrifuge tubes. Using separate, clean, eyedropper pipets transfer the contents of each tube to separate $1^1/_2$-in. squares of plastic film placed about 1 ft below a 250-W infrared lamp (Note 2). By dropwise addition of distilled water, rinse out the contents of each centrifuge tube as completely as possible, adding the washings to its respective plastic film. Call these samples A-1 and B-1. Carefully set aside the eyedropper pipet used in transferring the solutions. Evaporate the solutions to dryness with a heat lamp.

To the centrifuge tubes A and B, return the respective uranium solutions which were decanted from the LaF_3 precipitates. To each tube add dropwise approximately 1 ml of fresh La^{3+} stock solution with swirling to effect mixing of the solution. After allowing the mixtures to stand for about 3 min centrifuge the precipitates of LaF_3. Decant and discard the supernatant solutions. Wash the precipitates of LaF_3 with approximately 3 ml of distilled water. Centrifuge and decant the washings.

With the same eyedropper pipets used to transfer the solutions from the first precipitation to the plastic films likewise transfer the LaF_3 precipitates to similarly-prepared plastic films using a few drops of water to form a slurry. Rinse with successive tiny portions of water to transfer the precipitates as quantitatively as possible. Dry the slurries under a heat lamp. Call these samples A-2 and B-2.

When all samples are dry, mount the films for counting using another plastic film to cover the active deposits (Note 3). Count all samples in a counter. The ratio of observed counting rates of A-1 to A-2 and B-1 to B-2 should be 10 or greater, and the total activity collected in A-1 + A-2 should agree within a few per cent with that in B-1 + B-2. Use the counting data to compute the separation efficiencies ϵ for both aliquots according to equation (16).

Measure the absorption curves for both samples A-1 and B-1, using the same shelf as that used to count the $PbSO_4$ sample in the first experiment. Insert the aluminum absorbers close to the counter window. On semi-log paper plot the observed counting rate versus total absorber thickness (including the thickness of the covering film, counter window and air between sample and counter). At thicknesses greater than about 20 mg/cm² the absorption curve will be observed to be a straight line. Extrapolate this straight line to zero total absorber to obtain $R(o)$ (dis/sec) for both A-1 and B-1. Divide the value of $R(o)$ for each sample by the respective value of ϵ to obtain a value of $R(o)$ corrected for separation efficiency. Substitute this corrected value in equation (15) to obtain the combined factors $G \times f_s$, and average the two results. For a 2 ml aliquot of a uranium stock solution prepared as above, the value of A in equation (15) is obtained from Table 2 as 1224.0 dis/sec.

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Notes

1. Before centrifugation the precipitate in the centrifuge tube is almost imperceptible.

2. Before adding the solution to the film, smear one of the filter chimneys around the bottom flange with silicone stopcock grease and press it against the plastic film. This will leave a ring of grease which will confine the liquid sample to an area equal to the area covered by the $PbSO_4$ precipitates in the first experiment.

3. If samples to be counted are mounted over holes in sample-mounting cards, tape filter papers of the same type as were used to collect the $PbSO_4$ precipitate in the first experiment over the holes in the card. Place each film on the sample card with its active deposit upside down, centering the deposit over the filter paper. Tape the film along the edge to the sample card. In this manner the film supporting the deposit acts as the cover foil. The sample is inserted with the plastic film on top and the filter paper beneath. This method of mounting gives a scattering effect which approximates that which occurs in the $PbSO_4$ precipitate. Thus to a first approximation the effect of the unknown scattering factor, f_s, in the calculation of the age of the mineral tends to cancel out.

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Alkali Metal-Water Reactions

The usual experiment for illustrating the reactivity of the alkali metals with liquid water is performed by dropping a pea-sized piece of sodium into a container of water exposed to the ambient atmosphere. A typical result is seen in the right of the photograph reproduced on the cover where the sodium exhibits a brilliant display of pyrotechnics. In the left of the photograph, a piece of lithium of similar size reacts much more slowly and less violently with no splattering or evolution of light. It is instructive to inquire whether these simple experiments truly demonstrate the reactivity of the alkali metals with liquid water. An additional simple experiment can help to answer this question.

A pea-sized piece of sodium dropped into water contained in a flask continuously flushed with argon merely reacts with no combustion evident; i.e., the behavior is akin to that of lithium metal in either air or argon atmospheres. It should be clear then that the original open-air experiment with sodium does not in reality represent the typical reaction of an alkali metal with liquid water. The phenomena observed with sodium in air (*1*) are composite results of the interaction of the metal with liquid water

$$\text{Na}\,(solid,\ liquid) + x\,H_2O\,(liquid) = \text{NaOH (soln in } (x-1)H_2O) + {}^1/_2\,H_2(gas)$$

the ignition and combustion of the evolved hydrogen with atmospheric oxygen

$$H_2\,(gas) + {}^1/_2\,O_2\,(gas) = H_2O\,(gas)$$

and the ignition and combustion of the fragmented metal with atmospheric oxygen

$$2\text{Na}\,(solid,\ liquid) + {}^1/_2O_2\,(gas) = Na_2O\,(solid)$$

The flying glowing particles seen in the cover photograph for sodium clearly show the combustion of the metal in air and inasmuch as the particles are out of contact with the liquid water, the air oxidation of the metal is readily delineated as a separate occurrence. Each of the previous experiments has also been repeated with potassium metal. In air, even very small pieces of potassium ignite and burn vigorously after being thrown into water; under argon, only rapid reaction with water is observed. It is anticipated that the superoxides are formed when splattered fragments of potassium (*2*), rubidium, and cesium burn in air; lithium like sodium, yields the monoxide (*3*). In contrast to lithium, sodium in pure oxygen or in oxygen-enriched air reacts to produce the peroxide (*1*, *3*).

Reactivity and Energy Release

From the point-of-view of energy release per gram of metal reactant for the reaction

$$\text{M (alkali metal, } solid) + \infty\ H_2O\,(liquid) = \text{MOH (soln)} + {}^1/_2H_2\,(gas)$$

lithium is certainly superior to any of the other alkali metals as shown in Table 1 (*4*). Indeed, on this basis the lithium-water reaction has been considered as a most desirable propellant combination for torpedo propulsion systems (*5*, *6*). However, Table 1 also shows that the enthalpy changes per gram atom of alkali metal for the cited reaction are within about 10% of each other. The observed reactivity of a material or the violence of its reactions is frequently related to the rate at which heat is liberated during chemical combination rather than to the total amount of heat evolved over a prolonged period of time. It is of consequence then to consider those factors influencing the rate of heat evolution in alkali metal-water reactions. In this

Table 1. Heat Release Based on the Reaction:
M (solid) + ∞ H_2O (liquid) = MOH (solution) + $^1/_2H_2$ (gas)

Metal (M)	$-\Delta H^\circ_{25^\circ}$ (kcal/gram of M)	$-\Delta H^\circ_{25^\circ}$ (kcal/mole of M)
Li	17.51	121.5
Na	4.88	112.2
K	2.94	115.0
Rb	1.33	113.7
Cs	0.86	114.2

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regard, the total amount of metal surface or the number of metal atoms exposed to the liquid water should be highly significant.

Reactivity and Numbers of Exposed Atoms

Because the enthalpy changes per mole (gram atom) of the alkali metal-water reactions are comparable, it appears that, other factors being similar (e.g., kinetic mechanisms and rate constants), the number of alkali metal atoms exposed to water at any instant will primarily control the rate of heat release. This assumes relatively little hindrance of alkali metal-water contact due to the hydrogen gas liberated.

The alkali metals have body-centered cubic structures (*7*), and the unit cell edge lengths can be readily computed (*8*) from the measured densities (*9*) (Table 2). Assuming that the metals are in the form of a unit cube (1 cm along each edge) and that planes containing

Table 2. Some Structural Parameters of the Alkali Metals and Surface Exposure

Metal (M)	Density at 20° (g/cm³)	Cube edge length of unit cell (Å)	No. of atoms exposed upon immersion in water of a 1 cm unit cube
Li	0.534	3.51	26.1×10^{14}
Na	0.968	4.29	31.6×10^{14}
K	0.86	5.33	18.2×10^{14}
Rb	1.53	5.70	18.5×10^{14}
Cs	1.87	6.18	15.7×10^{14}

equivalent numbers of atoms are uniformly exposed across each cube face (e.g., 100, 010, and 001), then with appropriate corrections for buoyancy effects due to the different densities of the metals, the number of atoms exposed to liquid water upon immersion of each metal can be approximated (Table 2). In this calculation, the number of unit cell faces (n^2) was computed for 1 cm², where $n = 1$/unit cell edge length in cm. At each intersecting point in the network of 100, 010, and 100 planes there is an alkali metal atom, and the total number of atoms in 1 cm² of these planes is $(n + 1)^2$ or for n large, $(n + 1)^2 \simeq n^2$. For a metal of density less than 1g/cm³, the total number of exposed atoms upon water immersion is approximated by $(6n^2)$ (density$_M$); for a metal of density equal to or greater than 1g/cm³, this quantity is simply $6n^2$. It is seen from Table 2 that sodium exhibits the greatest number of exposed atoms, lithium has about 20% fewer, and the other alkali metals about 40–50% fewer than sodium. Thus, this information still presents two apparent anomalies: (1) that lithium is considerably less reactive than sodium with water in air environments despite a relatively small difference in initial numbers of atoms exposed to water, and (2) that the other alkali metals are known to be considerably more reactive (*10*) than either sodium or lithium despite relatively larger unfavorable differences in the numbers of exposed atoms.

Reactivity, Fusion, and Fragmentation

Further insights into the differences in alkali metal-water interactions are to be gained by observing lithium, sodium, and potassium in reaction with liquid water at room temperature under an argon atmosphere. An irregular-shaped piece of lithium retains its original geometrical configuration when put into the water; the sodium and potassium fuse and very quickly assume symmetrical spherical shapes under the same circumstances. This is reasonable because, as seen in Table 3 (*9*), the latter two metals melt below the normal boiling point of water, whereas the water in contact with the lithium metal (melting point 180.5°C) can act as a heat sink to prevent fusion. A thermocouple embedded in a ³/₈-in. sphere of lithium immersed in room temperature

Table 3. Some Physicochemical Properties of the Alkali Metals Pertinent to Reactivity with Liquid Water

Metal (M)	Melt. temp. (°C)	ΔH_{fusion}/ Mole of M	Boil. temp., (°C)
Li	180.5	0.69	1370
Na	97.8	0.63	883
K	63.6	0.56	775
Rb	38.8	0.53	680
Cs	29.7	0.50	700

water (about 250 cm³) under air or argon indicated a maximum bulk metal temperature of only 98–103°C. Under argon, with the now molten potassium and occasionally with the molten sodium, the original spheres are seen to break up and to shatter into large numbers of much smaller fragments. This effect gives rise to a greatly increased reactivity and violence of reaction. Thus, in proceeding down the alkali metal series from lithium to cesium, the ease of fusion (decreasing melting point and heat of fusion) increases appreciably. Rubidium and cesium approach their melting points close to room temperature. Only within fairly recent times has care been taken in thermochemical studies of the alkali metal-water reactions to insure against experimental errors due to sample splattering and to secondary interaction with air (*11*).

Immersion of lithium and sodium in a slurry of ice and water exposed to air results in a pronounced diminution of activity. The sodium fuses but does not burst into flame as it does in room temperature water. The violence of the potassium-water reaction in air appears undiminished in water at 0°C. The bulk temperature of a ³/₈-in. sphere of lithium in reaction under these conditions reaches a maximum of only about 50°C, thereby indicating the effectiveness of the surrounding water as a heat sink.

It is interesting to compute the increase in total surface area starting with a cube of edge length s which undergoes a successive divisions into equal, smaller cubes. After a divisions, there are 2^a separate cubes, each of cube edge length $(1/2^a)^{1/3}s$. Thus, the total surface area is then $6(2^a)^{1/3}s^2$. Table 4 gives a tabulation of total surface area as a function of a for an initial unit cube of 1 cm edge length. From the data of Table 4, it is evident that the number of exposed atoms increases significantly with fragmentation. As a result, the observed rates of energy release and hence violence of reactions also are found to increase with ease of reactant particle division.

Under the argon atmosphere, small pieces of sodium are not as apt to fragment as are the succeeding alkali metals. Apparently, in air, rupture of sodium is easier due to the increased turbulence and exothermicity contributed by the air oxidations of the hydrogen and metal. Preliminary results in this laboratory from

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kinetic studies of the dissolution of discrete lithium and sodium spheres in water at 25°C under argon lead to an integrated rate law of the form

$$r = r_0 - kt$$

where r is the radius in cm of the reacting metal sphere at any time t, and k is the specific reaction rate constant in cm/sec. For lithium and sodium spheres, the numerical values of k are 0.0036 and 0.0054, respectively. Thus, it seems that in a gaseous environment which is non-reactive with the metals and the evolved hydrogen, the reactivities of lithium and sodium appear rather similar despite the observed change in state for sodium. It is felt that with large pieces of lithium in restricted volumes of water the relative insolubility of lithium hydroxide may impede the reaction. As the data of Table 5 (*12*) demonstrate, lithium hydroxide manifests about one-fourth to one-fifth the molal solubility of the other alkali metal hydroxides. Based on molar volume considerations (i.e., the Pilling-Bedworth rule (*13*)), it is anticipated that suitable coatings of lithium hydroxide may have some protective effects on lithium metal, whereas the other alkali metals are not expected to be shielded by their corresponding hydroxides.

Table 4. Variation in Total Surface Area of an Array of Dividing Cubes

a, no. of divisions	Total surface area, (cm^2)	Relative total surface area
0	6.00	1.00
1	7.55	1.26
2	9.52	1.59
3	12.00	2.00
4	15.12	2.52
5	19.05	3.18
6	24.00	4.00
7	30.24	5.04
8	38.10	6.35
9	48.00	8.00

Table 5. Solubilities of Alkali Metal Hydroxides in H_2O

	Solubility (moles/1000 g H_2O)	
LiOH	5.24	25°
NaOH	28.5	25°
KOH	21.1	25°
RbOH	17.5	15°
CsOH	25.7	25°

As noted previously, hydrogen and metal oxidations by air increase the violence of the water-initiated sequence of events. Lithium, unlike the other alkali metals (*1*, *2*, *10*, *14*), is known to be highly resistant to oxidation even at elevated temperatures in pure oxygen or in air atmospheres (*15*, *16*). It appears that the relative ease of combustibility of the alkali metals can be related to the decreasing order of their boiling points (Table 3). A similar effect is witnessed in the easy combustion of magnesium in air or oxygen as compared with aluminum (*17*), due, in part, to the greater volatility of magnesium. The usual non-ignition in air of the hydrogen evolved from lithium reacting with water is an additional moderating factor. Here one might surmise that hydrogen atoms required for sustaining a hydrogen-oxygen flame are removed close to areas of bare lithium metal to form preferentially lithium hydride which is subsequently hydrolyzed by the water. Lithium, of all the alkali metals, is known to form a stable hydride most readily (*10*).

Interestingly, lithium is known to be more susceptible to nitridation than to oxidation at moderate temperatures (*15*, *18*). Accordingly, lithium was reacted with water in nitrogen and in air atmospheres. The resulting solutions were tested for ammonia by addition of Nessler's reagent. No ammonia was found, thereby indicating that under these conditions the lithium-water reaction took complete precedence over the lithium-nitrogen reaction.

Reactions at Elevated Temperatures

Some additional experiments with alkali metals can be performed safely behind a shield using boiling water under argon. A piece of sodium injected into this environment melts as it falls through the steam-argon atmosphere and the fragmented droplets are seen to ignite, burning with a bright yellow flame throughout the volume of the flask and on the surface of the boiling water. Lithium, on the other hand, merely reacts with the boiling water without combustion. However, if as in Figure 1, the lithium is allowed to stand in the flowing steam, a white coating of material forms (LiOH, $LiOH \cdot H_2O$, and perhaps Li_2O close to the lithium surface). Within about 5 min the edges of the white coating become incandescent and liquid lithium metal flows through the cracks in the coating and starts to burn brilliantly (Fig. 2). The results reported here are interpreted in terms of the initial protective effects of the lithium hydroxide coating. As the coating becomes thicker and develops strains and cracks, it loses its protective character but continues to act as an efficient thermal insulator to raise the metal to melting and ignition temperatures by retaining the heat of the lithium metal-steam reaction. In the latter phase of the sequence of events, the reaction then tends to run away or to become "catastrophic," as occurs with the oxidation of a number of metals.

Figure 1. Initial stage of lithium-steam reaction.

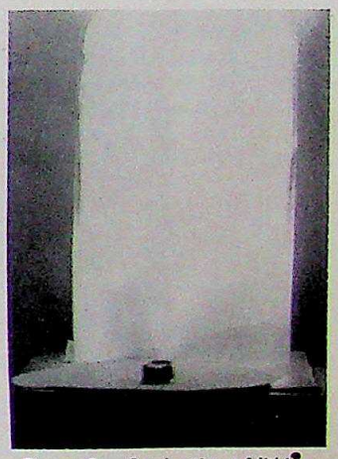

Figure 2. Combustion of lithium metal in a steam atmosphere.

The present experiments are probably illustrative of alkali metal-steam flames:

$$M\ (liquid,\ gas) + H_2O\ (gas) = MOH\ (gas) + \tfrac{1}{2}H_2\ (gas)$$

Gaseous alkali metal hydroxides of various degrees of polymerization have been reported for the alkali metal hydroxides at suitably elevated temperatures (*19*, *20*) in contrast to the reactions

$$2MOH\ (solid) = M_2O\ (solid) + H_2O\ (gas)$$

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at lower temperatures (*21*, *22*). It is noteworthy that hydrogen gas constitutes one of the combustion products in the alkali metal-steam flames.

Increased Reactivity of Lithium Metal Dispersions

It is, of course, well established that a very finely divided material (i.e., high total surface area per unit weight or high surface-to-volume ratio) generally evidences greatly enhanced reactivity over a like weight of the bulk material. Thus, lithium metal dispersions are quite reactive and ignite when thrown into water at room temperature in either air (*23*) or argon. The latter point was proved by placing a small amount of lithium dispersion (average particle size of 22 microns) in an argon-flushed gelatin capsule and then submerging it under water in an argon atmosphere. Once the capsule dissolved, flame was observed under the surface of the water and the hot hydrogen evolved burned in air close to the mouth of the flask.

Other Reaction Conditions

The present discussions have centered on the reactions of the alkali metals with a considerable excess of liquid water. The reactions with very limited amounts of water are of interest in the safety aspects and use of sodium and sodium-potassium alloys as heat transfer fluids to steam generators in nuclear reactors (*24*).

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Literature Cited

(1) Tennant, H. R., and Schow, R. B., in "Handling and Uses of the Alkali Metals," Advances in Chemistry Series No. 19, American Chemical Society, Washington, D. C., 1957, pp. 118–23.
(2) Jackson, C. B., and Werner, R. C., *ibid.*, pp. 174–7.
(3) Petrocelli, A. W., and Kraus, D. L., J. Chem. Educ., **40**, 146 (1963).
(4) Rossini, F. D., Wagman, D. D., Evans, W. H., Levine, S., and Jaffe, J., "Selected Values of Chemical Thermodynamic Properties," Nat. Bur. Std. Circ. 500, U. S. Government Printing Office, Washington, D. C., 1952.
(5) Greiner, L., *ARS J.*, **30**, 1161 (1960).
(6) White, W. D., *Astronautics*, **6**, 38 (1961).
(7) Wells, A. F., "Structural Inorganic Chemistry," 2nd ed., Oxford Univ. Press, 1950, p. 677.
(8) Daniels, F., and Alberty, R. A., "Physical Chemistry," 2nd ed., John Wiley and Sons, Inc., New York, 1961, pp. 629, 635.
(9) Smithells, C. J., "Metals Reference Book," Vol. II, Interscience Publishers, New York, 1955.
(10) Sidgwick, N. V., "The Chemical Elements and Their Compounds," Vol. I, Oxford Univ. Press, 1950, pp. 65–7.
(11) Ketchen, E. E., and Wallace, W. E., *J. Am. Chem. Soc.*, **73**, 5810, 5812 (1951).
(12) Seidell, A., "Solubilities of Inorganic and Metal Organic Compounds," 3rd ed., Vol. 1, D. Van Nostrand Co., Inc., New York, 1940.
(13) Pilling, N. B., and Bedworth, R. E., *J. Inst. Metals*, **29**, 577 (1923).
(14) Fatt, I., and Tashima, M., "Alkali Metal Dispersions," D. Van Nostrand Co., Inc., New York, 1961, pp. 5, 12, 31.
(15) Markowitz, M. M., and Boryta, D. A., *J. Chem. Eng. Data*, **7**, 586 (1962).
(16) Tyzak, C., and Longton, P. B., "The Oxidation of Lithium," U. K. At. Energy Authority, Tech. Note 131, June 1955.
(17) Markowitz, M. M., and Boryta, D. A., *Anal. Chem.*, **33**, 949 (1961).
(18) Chandrasekharajah, M. S., and Margrave, J. L., *J. Electrochem. Soc.*, **108**, 1008 (1961).
(19) Smith, H., and Sigden, T. M., *Proc. Roy. Soc.* (London), **219A**, 204 (1953).
(20) Spinar, L. H., and Margrave, J. L., *Spectrochim. Acta*, **12**, 244 (1958).
(21) Gregory, N. W., and Mohr, R. H., *J. Am. Chem. Soc.*, **77**, 2142 (1955).
(22) Kay, E., and Gregory N. W., *J. Am. Chem. Soc.*, **80**, 5648 (1958).
(23) *Chem. Eng. News*, **36**, 40 (1958).
(24) Adams, D. D., Barenborg, G. J., and Kendall, W. W., in "Handling and Uses of the Alkali Metals," Advances in Chemistry Series No. 19, American Chemical Society. Washington D. C., 1957, pp. 92–105.

Abstracting Publications on Chemical Education in the Soviet Union

Current trends in Russian chemical education are of interest to specialists in the fields of chemistry, education, and Soviet studies. As part of a study of Soviet education being organized by the Soviet Studies Department of Glasgow University, work has been started in Paisley Technical College on the abstracting of material from the Russian educational journals "Khimiya v Shkole" (Chemistry in School), "Srednee Spetsial'noe Obrazovanie" (Secondary Specialized Education), and "Vestnik Vysshei Shkoly" (Higher Schools News). Much of the material—for example, review articles, biographical notes, papers on teaching methods, visual aids, apparatus and experiments, and reports of the activities of school chemical circles—corresponds fairly closely to the contents of analogous journals outside the Soviet Union, but other material reveals unique features of emphasis and approach.

Much has been written in these journals on the ways in which chemistry teaching is being brought "closer to life and production," in fulfillment of the aims of the 1958 educational reforms. Thus pupils are expected to be familiar with the Five-Year Plan figures for iron and steel production, the relative expansion planned for the chemical industry—compared with industry as a whole, and other economic data. This material links the study of chemistry with the study of "Social Science," which has recently been introduced in schools and aims to teach senior pupils the fundamentals of Marxism-Leninism. Part of the chemistry teacher's work is to prepare the way for the study of dialectic materialism and to inculcate atheism.

A characteristic feature of the Soviet educational system is the close central control over programs and curricula, textbooks, and examinations. Little if any deviation from the official curriculum is permitted. Textbooks are standardized throughout the Soviet Union, and new books are subjected to prolonged criticism in the minutest detail. Examinations are conducted on a "ticket" system: each pupil has to answer the questions printed on one, picked by chance, of a limited number of tickets whose contents are known to pupils and teachers in advance. Despite this uniformity of control, there appears to be a progressive decrease in the quality of education away from the large urban centers.

Many interesting details are revealed in the correspondence columns, where progress is reported or grievances aired, and in review articles, where details of present achievements are accompanied by exhortation to eliminate shortcomings. In an assessment of the real state of the Soviet educational system, both features have to be considered.

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The Hydrated Hydronium Ion

Most students of chemistry are introduced to the concept of the hydrated proton in aqueous solution. The high charge to size ratio of the proton and its high force of attraction for water molecules is emphasized in most beginning textbooks. The monohydrated proton or hydronium ion, H_3O^+, is usually the only species discussed. It is also an important species in any discussion of the Brønsted theory of acids and bases. Recently the trihydrate of the hydronium ion, $H_3O^+ \cdot 3H_2O$ or $H_9O_4^+$, has been postulated to explain many observed properties of aqueous strong acid solutions. It is the purpose of this brief review to cite and discuss some of the evidence for the existence of this trihydrated hydronium ion.

The older evidence for the existence of the monohydrated proton, H_3O^+, is outlined as an introduction. More detailed discussions can be found in Wicke, Eigen, and Ackerman (*1*) and in Bell (*2*).

Evidence for H_3O^+

Quite conclusive evidence for the hydronium ion in solids is based on the nature of solid monohydrates of strong acids. The fact that ammonium perchlorate and perchloric acid monohydrate crystals are isomorphous and give similar X-ray patterns suggests an ionic H_3O^+ ClO_4^- structure (*3*). Nuclear magnetic resonance studies of solid $HClO_4 \cdot H_2O$, $HNO_3 \cdot H_2O$ and $H_2SO_4 \cdot H_2O$ give spectra characteristic of three equivalent protons. This suggests either a planar or pyramidal H_3O^+. Detailed consideration of observed proton-to-proton distances leads to the conclusion that the hydronium ion is a flat pyramid with H—O—H bond angles of about 115° (*4*). Infrared studies of hydrohalogen monohydrate solids show four fundamental frequencies characteristic of a pyramidal H_3O^+ ion (*5*). Estimates of the proton affinity of water based on the properties of hydrohalogen monohydrate crystals after a logical estimate of their crystal lattice energy give values (*6*, *7*) which agree with direct theoretical estimates of the proton affinity (*8*).

Direct confirmation of the presence of the hydronium ion in dilute aqueous solution of strong acids is difficult. Bell (*2*) points out that the characteristic properties of the hydronium ion will differ little from those of water which is always present in large excess, and that the rate of exchange of the proton between water molecules may be so rapid that the H_3O^+ lifetime is too short to characterize its properties.

Infrared spectra have been obtained of thin films of concentrated strong acids (*9*), which contain three of the same four bands observed for the H_3O^+ in solids (*5*).

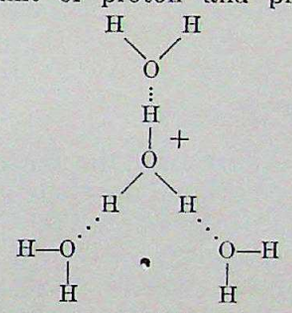
Kinetic and electrolytic evidence for the hydronium ion in solution comes from studies of nonaqueous solvents containing small amounts of water. The reaction

$$H^+(ROH) + H_2O \rightleftharpoons ROH + H_3O^+$$

is part of a reaction scheme consistent with the rate of acid-catalyzed esterification reactions in alcohol containing small amounts of water (*10*). Other assumptions about the hydration of the proton do not fit the rate data. Liquid sulfur dioxide dissolves equimolar amounts of HBr and H_2O. Upon electrolysis one equivalent of water per equivalent of hydrogen is liberated at the cathode (*11*), which suggests that the proton migrates into the cathode compartment as H_3O^+.

The Hydrated Species $H_9O_4^+$

Over the past 10–15 years considerable experimental evidence has accumulated which can best be explained by a trihydrate of the hydronium ion, $H_3O^+ \cdot 3H_2O$ (also represented by the formulas $H_9O_4^+$ or $H^+(H_2O)_4$). Wicke, Eigen, and Ackerman (*1*) suggest the structure of this unit of proton and primary water of



hydration to be a pyramidal hydronium ion hydrogen bonded to three moles of water.

The H_3O^+ acts as a Lewis acid in reacting with three water molecules to form the $H_9O_4^+$ complex. To add a fourth water molecule to the H_3O^+ oxygen would require the complex to react as a Lewis base and if the $H_{11}O_5^+$ formed, the fourth water would probably be much less strongly bonded than the other three molecules. Thus it seems reasonable to regard the $H_3O^+ \cdot (H_2O)_3$ or $H_9O_4^+$ as the primary hydrated species.

The three hydrogen bonds are thought to be of greater than ordinary strength because the charge of the proton is directed along the three bonds rather than being distributed uniformly over the surface of a sphere as is the charge of a metallic ion. Baughan (*12*) has worked out a cycle, based on the properties of hydrogen halides, that results in a value of 283 kcal for the reaction

$$H^+(g) + \infty\, H_2O \rightarrow H_3O^+(aq)$$

This reaction is the sum of proton affinity,

$$H^+(g) + H_2O(g) \rightarrow H_3O^+(g)$$

and hydration of the gaseous hydronium ion,

$$H_3O^+(g) + \infty\, H_2O \rightarrow H_3O^+(aq)$$

The proton affinity is about 180 kcal (*6*, *7*, *8*). The difference of about 100 kcal can be assigned to the

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hydration step. The hydration energy is made up of contributions from the three hydrogen bonds in the $H_9O_4^+$ structure and the additional hydrogen bonds of secondary water of hydration to the primary hydration shell. If the three hydrogen bonds in the $H_9O_4^+$ structure are responsible for more than 15–8 kcal of the 100 kcal hydration energy, they are stronger than conventional hydrogen bonds.

The exprimental evidence to support the existence of the $H_9O_4^+$ ion comes from the following:

Extraction studies on strong acids from water into basic solvents,
Field emission and mass spectrometry of water vapor,
The interpretation of the Hammett acidity function of strong acids,
The infrared spectra of aqueous strong acid solutions,
The activity coefficients of strong electrolytes, and
The heat capacity of aqueous solutions of strong acids.

Both the extraction studies and the field emission and mass spectrographic studies give indirect evidence of the $H_9O_4^+$ ion in aqueous solution since they indicate the existence of ions in non-aqueous liquids and in water vapor, respectively. However, if the $H_9O_4^+$ is a probable species under such conditions, it may well be a probable species in water solution. The other experimental studies were made on aqueous solution. The $H_9O_4^+$ existence depends on acceptance of the theoretical interpretation of the data obtained. Not all of the theories used have won universal acceptance but the evidence from so many diverse viewpoints seems convincing.

Extraction Studies

Fairly strong evidence for the $H_9O_4^+$ ion in non-aqueous liquids comes from the study of extraction of aqueous strong acids into basic solvents. The review of Marcus (*31*) on extraction contains a comprehensive section on the distribution of strong acids between water and basic solvents. A particularly useful study is that of Tuck and Diamond (*13*) who have extracted strong acids from water into basic solvents like dibutyl Cellosolve, diisopropyl ketone and tri-*n*-butyl phosphate. In a typical experiment, five ml of aqueous strong acid solution is extracted with five ml of the basic solvent in a graduated tube of small bore. If the total volume of the system does not change, the decrease in volume of the water layer can be interpreted as water carried into the organic layer with the acid. When perchloric acid is extracted into either dibutyl Cellosolve or diisopropyl ketone, the volume change in the water layer is linear with the amount of acid extracted and amounts to a little over four moles of water per mole of acid. If only the proton is hydrated in the water layer, this is good evidence of the $H^+(H_2O)_4$ (or $H_9O_4^+$).

When HCl, HBr, or $HClO_4$ is extracted into tri-*n*-butyl phosphate the water volume carried with the acid is linear with extracted acid to fairly high acid concentrations but amounts to only three molecules of water pr acid molecule extracted. This is still consistent with the $H_9O_4^+$ ion since water saturated tri-*n*-butyl phosphate (TBP) has one mole of water per mole TBP which results in a net exchange of only three moles of water per mole of acid during extraction.

$$[TBP(H_2O)]_{org} + [H^+(H_2O)_4 + X^-]_{aq} \rightarrow \begin{bmatrix} TBPH^+(H_2O)_4 \\ +X^- \end{bmatrix}_{org} + [H_2O]_{aq}$$

This is confirmed by the work of Baldwin, Higgins, and Soldano (*14*) who have analyzed the acid-TBP layers for water by the K. Fisher technique and find water-to-acid ratios of 4.1 and 4.6 for HCl and HBr, respectively.

Extraction of the strong acid $HFeCl_4$ into diisopropyl ether carries 4 water molecules per molecule of acid. Electrolysis and ultraviolet spectra of the organic phase indicate that all of the water is associated with the H^+ and none with the anion (*15, 16*).

Extraction studies on nitric and trichloroacetic acid into dibutyl Cellosolve (*13*) are also consistent with the $H_9O_4^+$ ion if corrections for the dissociation of these acids in the water phase are made.

Extraction studies also give evidence of the hydronium ion itself. Whitney and Diamond (*30*) finds that when perchloric acid is extracted into a less polar organic phase such as TBP diluted in some hydrocarbon only one mole of water is carried per mole of acid extracted.

Field Emission and Mass Spectrographic Studies of Water Vapor

In field emission studies of water vapor, Beckey (*32*) has observed $H_3O^+\cdot(H_2O)_n$ with n values of 0 to 10.

Knewstubb and Tickner (*33*) have studied the mass spectrometry of ions formed from the negative glow and Faraday dark space of discharges in water vapor and observed ions of the form $H_3O^+\cdot(H_2O)_n$ with $n = 0$–5. Their data indicates that the bond strength in the ion falls off sharply after $n = 3$, and that the $H_9O_4^+$ ($m/e = 73$) represents a particularly stable form.

Knewstubb and Tickner made an approximate kinetic analysis of their data on the basis of the reaction scheme

$$H_3O^+ + 2\,H_2O \rightleftarrows H_5O_2^+ + H_2O$$
$$H_5O_2^+ + 2\,H_2O \rightleftarrows H_7O_3^+ + H_2O$$
$$H_7O_3^+ + 2\,H_2O \rightleftarrows H_9O_4^+ + H_2O$$

They assumed that the measured ion currents could be taken as a measure of the ion concentration. The hydration reactions were treated as bimolecular reactions which obey first order kinetics. It was assumed that the ion bond strengths were such that thermal energy was not enough to cause an appreciable amount of reverse reaction. The rate constants were matched to data in the tail of the negative glow (2.0 to 3.5 cm from the cathode). Starting with 100% H_3O^+ in the vapor the calculation shows a fast build up of the $H_9O_4^+$ ion to better than 90% of the mixture with neither $H_5O_2^+$ or $H_7O_3^+$ being more than 20% of the mixture at any time.

Hammett Acidity Function

Bascombe and Bell (*2, 17*) have interpreted the Hammett acidity function of strong acids like HCl, HBr, $HClO_4$, and H_2SO_4 as evidence for the $H_9O_4^+$ hydrate. They point out that salt effects on the activity coefficient of a nonelectrolyte (*18*) often takes the form

$$\log f = AC$$

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where f is the activity coefficient of the nonelectrolyte and C is the concentration of the salt. The constant A is a slope of about 0.1. Bascombe and Bell show the Hammett acidity function and water activity in strong acids solution gives such a result for the activity coefficient of the undissociated indicator base, B, if one assumes that the proton is hydrated with four molecules of water and that the activity coefficients of the hydrated proton and the indicator acid, BH^+, are essentially equal.

The Hammett acidity function is a measure of the transfer of a proton to an indicator base

$$B + H^+ \rightleftarrows BH^+$$

and is formally defined as (*19*)

$$H_0 = -\log \frac{a_{H^+} f_B}{f_{BH^+}} = pK_{BH^+} - \log \frac{C_{BH^+}}{C_B}$$

If the defining equation is written to include the proton water of hydration, with h the proton hydration number

$$B + H^+(H_2O)_h \rightleftarrows BH^+ + h\,H_2O$$

The Hammett acidity function becomes

$$H_0 = -\log \frac{a_{H^+} f_B}{a^h_{H_2O} f_{BH^+}}$$

$$= -\log C_{H^+} + h \log a_{H_2O} - \log \frac{f_B f_{H^+}}{f_{BH^+}}$$

If one can assueme $f_{H^+} = f_{BH^+}$, which is reasonable for similar size ions such as is the case with the hydrated proton and the indicator acid ion, the last term becomes $\log f_B$ and upon rearrangement

$$\log f_B = -H_0 - \log C_{H^+} + h \log a_{H_2O} = AC$$

when h is given the value 4.0, plots of ($-H^\circ$-$\log C_{H^+}$ + 4 $\log a_{H_2O}$) against C are linear and have slopes of about 0.1 for HCl, $HClO_4$, and H_2SO_4, up to molalities of about 8.0.

Another approch by Bascombe and Bell that does not require knowledge of the water activity in strong acid solution is to write the Hammett acidity function as

$$H_0 = -\log C_{H^+} + h \log C_{H_2O} - \log \frac{f_B f_{H^+}}{f^h_{H_2O} f_{BH^+}}$$

They assume that in addition to $f_{H^+} = f_{BH^+}$, that $f_B = f^h_{H_2O}$, thus the last term is zero. They substitute for C_{H^+} the acid molarity and for C_{H_2O} a function of acid molarity and molality which includes the reduction in the amount of free water by hydration. Their final equation (*2*), which assumes $h = 4$,

$$-H_0 = \log m - 4 \log (1 - 0.072\,m) + 3 \log (1 + 0.032\,m)$$

very satisfactorily predicts the observed H_0 values of HCl, HBr, $HClO_4$, and H_2SO_4 up to molalities of 8.0.

Infrared Spectra of Strong Acid Solutions

Wicke, Eigen, and Ackermann (*1*) have interpreted the infrared data of Suhrmann and Breyer (*20*) for HCl and H_2SO_4 solutions as evidence for the $H^+(H_2O)_4$ hydrated ion.

In aqueous solutions of neutral salts the water absorption is strengthened due to a partial depolymerization of the water structure. In strong acid solutions there is a structure-forming effect due to the primary hydration shell around the proton which weakens and broadens the normal water absorption bands. Sometimes this effect is obscured by a small absorption bond-strengthening effect due to the acid anion.

Suhrmann and Breyer and Wicke, Eigen, and Ackermann have calculated extinction coefficient as a function of wavelength between 1.4 and 2.3 μ for water assuming the measured extinction coefficient is the sum of a contribution from "free" water molecules plus one from hydrated molecules. Their equation is

$$K_s = hqK_b + (1 - hq)K_f$$

where K_s is the measured extinction coefficient of the solution, K_f is the extinction coefficient of free water, K_b is the extinction coefficient of bound water, h is the bound water molecules, and q is the ratio of protons to water molecules present in the solution. When h is unity, the calculated plot shows an incorrect minimum at about 1.95 μ, while the use of $h = 4$ gives a qualitative reproduction of the experimental curve.

Activity Coefficients of Concentrated Electrolytes

Glueckauf (*23*) has developed an expression for the activity coefficient of an electrolyte in concentrated solution that is in part a function of the hydration number of cation plus anion. His treatment is a refinement of the earlier work of Stokes and Robinson (*24*) in which he takes into account the effect of ionic sizes on the covolume entropy effect. His expression for the Gibbs free energy of a solution of electrolyte 1 in a solvent 2 is

$$G = n_1\mu_1^0 + n_2\mu_2^0 + G^{el} + kT\left[n_1V_1^+ \ln \frac{n_1V_1^+\bar{V}_1^+}{V} + n_1V_1^- \ln \frac{n_1V_1^-\bar{V}_1^-}{V} + n_2 \ln \frac{n_2\bar{V}_w}{V}\right]$$

The partial volumes, $\bar{V}$, are treated as concentration independent, and the chemical potential obtained by taking the derivative with respect to n_1 at constant total water. Glueckauf's final equation is

$$\log \gamma_\pm = \log \gamma^{el} + \frac{0.018\,mr(r + h - V)}{2.3\,V\,(1 + 0.018\,mr)} + \frac{h - V}{V} \log (1 + 0.018\,mr) - \frac{h}{V} \log (1 - 0.018\,mh).$$

where h is the hydration number of the electrolyte, r is the apparent molar volume divided by the molar volume of pure water, V is the sum of positive and negative ions from the electrolyte, and m is the molality.

When the equation is applied to the observed activity coefficients the values of h are 4.7, 4.7, and 4.9 for HCl, HBr, and HI, respectively. Thermodynamic considerations cannot determine hydration values of cations and anions separately but reasonable assumptions about the hydration of individual ions leads to a value of about 0.9 for the halide ion and 3.9 for the proton.

Eigen and Wicke (*21*) have developed a theory of activity coefficients of electrolytes for high concentrations. Their theory takes into account electrostatic interactions by an ingenious modification of the distribution equation used by Debye and Huckel, space requirements of the hydrated ions in the ionic atmosphere, and incomplete dissociation of the electrolyte at high concentration. The theory has been critized because of overemphasis on cloud-cloud exclusion and oversimplification of anion-cation exclusion in the cloud

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which leads to some mathematical inconsistency (*34*, *35a*) and because the dissociation constants required to fit experimental data are not always consistent with K's from Raman spectral studies (*35b*).

The final equations of Eigen and Wicke can be fitted to the experimental activity coefficients, heats of dilution and apparent molal heat capacities of many strong electrolyte solutions. Their activity coefficient equation fits (*1*, *22*) both HCl and LiCl activity coefficient data up to 2.0 molal when they assume complete dissociation and a hydration number of 6 A for both electrolytes. This implies, but does not prove, that in this case the similar activity coefficient behavior may mean similar hydration of H^+ and Li^+ ions.

Heat Capacity of Strong Acids

The initial evidence for the trihydrated hydronium ion comes from the specific heat measurements of aqueous strong acid solutions by Wicke, Eigen, and Ackermann (*1*). Experimentally they have measured the specific heat of aqueous HCl solutions of concentrations of about 0.5, 1.0, and 2.0 molal at 8 to 10 different temperatures between 10 and 130°C. The apparent molal heat capacity of HCl was calculated, plotted against $m^{1/2}$ and extrapolated to get the apparent molal heat capacity of HCl in aqueous solution at infinite dilution at 10° intervals between 10 and 130°C. The apparent molal heat capacity at infinite dilution is separated into a contribution of H^+ and Cl^- by a technique worked out by Eigen and Wicke (*25*).

The H^+ contribution to the partial molar heat heat capacity at infinite dilution is fitted to the detailed model of Eucken (*26*) which allows hydration numbers to be estimated from the temperature dependence of apparent molal quantities. Eucken's theory assumes that the hydrated ion affects the properties of water in two ways. The first is a partial depolymerization of the water which causes a negative contribution to the apparent molal heat capacity and apparent molal volume of the solute. The second is a temperature-dependence to ion hydration. The hydration water is absorbed in two layers. The primary layer does not change with temperature and gives a further negative contribution to the apparent molal volume. A secondary hydration layer decreases with temperature and gives a positive contribution to both apparent partial molal volume and heat capacity.

The hydrated H^+ contribution to the partial molal heat capacity is fitted best with a temperature independent primary layer of four water molecules, the $H_9O_4^+$ unit, and a secondary hydration layer that decreases from 4 moles of water at 0° to 1 mole at 130°C. The hydrated H^+ contribution to the limiting value of apparent molal volume is fitted by the same hydration model.

The Eucken model (*26*) of aqueous solution pictures liquid water as an ideal solution composed of H_2O, $(H_2O)_2$, $(H_2O)_4$, and $(H_2O)_8$ species in equilibrium. The $(H_2O)_8$ species is assumed to be quite ice-like. Properties of liquid water and aqueous solution are interpreted in terms of displacement of this association equilibrium. The model has not been generally accepted and is contrary to other modern viewpoints (*34*, *36*). If the heat capacity interpretation was the only evidence of the $H_9O_4^+$ ion, its existence would probably have won little acceptance. However, when all of the available evidence from many experimental approaches is considered the $H_9O_4^+$ ion must be reckoned with as a species of considerable importance in aqueous acid solution.

Although the extraction and Hammett acidity interpretations assume no contribution of anion water of hydration, fractional increases over the 4.0 moles of water are ascribed to anion effects. In the thermodynamics approaches of activity coefficient and specific heat some arbitrary decision is made that separates cation and anion contributions. Although the anion water of hydration does complicate the interpretation the importance of the $H_9O_4^+$ ion is evident.

Other Evidence

The hydroxide ion is also hydrated. Gluckauf (*23*) gives a hydration number of 4.0 from his activity coefficient approach. Ackermann (*22*) fits the infrared data of concentrated KOH solutions with $h = 3$. Ackermann (*22*) interprets his specific heat and specific volume data on aqueous NaOH in terms of the Eucken model and gets the best fit with a primary hydration layer of 6 moles of water and the temperature dependent secondary layer decreasing from 7 moles of water at 0° to 3 moles of water at 130°C.

The three molecule hydrate of the hydronium ion is not a rigid structure that migrates through solution. There is a continuous migration of positive charge within the primary hydration unit; and when the group is properly oriented with respect to secondary waters of hydration, the charge migrates with a new water molecule coming in and an old water molecule being ejected from the primary $H_9O_4^+$ unit. Eigen (*27*) has explained protonic charge transport and fast protolytic reactions by a two step mechanism that is consistent with the $H_9O_4^+$ structure. The mechanism involves the formation of a structure with favorable orientation and the charge transfer within a hydrogen bond. Eigen believes that the first is the rate determining step in liquid water and that the latter is the rate determining step in ice.

Conway, Bockris, and Linton (*28*) discuss conductivity evidence for H_3O^+ in water organic mixtures and discuss the mechanism of proton migration in solution. Although they do not mention the $H_9O_4^+$ ion, their mechanism of proton transfer does not appear to rule out the possibility of such a unit.

The continuous realignment and exchange of water between primary and secondary waters of hydration is consistent with the kinetic viewpoint of hydration of Samoilov (*29*). He believes hydration is a matter of the time of contact between the water molecule and the ion. The water molecules around a highly hydrated ion have a longer time of contact with the ion than they do with neighboring water molecules. He postulates that the water molecules around slightly hydrated ions actually have a shorter time of contact with the ion than with neighboring water molecules.

Literature Cited

(1) Wicke, E., Eigen, M., and Ackermann, Th., *Z. Physik. Chem. (Frankfurt)*, 1, 340 (1954).
(2) Bell, R. P., "The Proton in Chemistry," Cornell University Press, Ithaca, N. Y., 1959, Chaps. 3 and 6.
(3) Volmer, A., *Ann. Chem.*, 440, 200 (1924).

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(4) Richards, R. E., and Smith, J. A. S., *Trans. Faraday Soc.*, **47**, 1261 (1951).
(5) Bethell, D. E., and Sheppard, N., *J. Chem. Phys.*, **21**, 1421 (1953); and Ferrisco, C. C., and Hornig, D. F., *J. Chem. Phys.*, **23**, 1464 (1955).
(6) Grimm, H. G., *Z. Electrochem.*, **31**, 474 (1925).
(7) Sherman, J., *Chem. Rev.*, **11**, 164 (1932).
(8) Fajans, K., *Ber. deutcher phys. Gesell*, **21**, 709 (1919).
(9) Falk, M., and Giguere, P. A., *Can. J. Chem.*, **35**, 1195 (1957).
(10) Goldschmidt, H., and Udhy, O., *Z. Physik. Chem.*, **60**, 728 (1907); Goldschmidt, H., *Z. Electrochem.*, **15**, 4 (1909).
(11) Bagster, L. S., and Cooling, G., *J. Chem. Soc.*, **1920**, 693.
(12) Baughan, E. C., *J. Chem. Soc.*, **1940**, 1403.
(13) Tuck, O. G., and Diamond, R. M., *J. Phys. Chem.*, **65**, 193 (1961).
(14) Baldwin, W. H., Higgins, C. E., and Soldano, B. A., *J. Phys. Chem.*, **63**, 118 (1959).
(15) Tuck and Diamond, *op. cit.*, refs. *24*, *25*.
(16) Friedman, H. L., *J. Am. Chem. Soc.*, **74**, 5 (1952).
(17) Bascombe, K. N., and Bell, R. P., *Discussions Faraday Soc.*, **24**, 158 (1957).
(18) Long, F. A., and McDevit, W. F., *Chem. Rev.*, **51**, 119 (1952).
(19) Hammett, L. P., and Deyrup, A. J., *J. Am. Chem. Soc.*, **54**, 2721 (1932). A recent detailed review is Paul, M. A., and Long, F. A., *Chem. Rev.*, **57**, 1 (1957).
(20) Suhrmann, R., and Breyer, F., *Z. Physik. Chem.* **B23**, 193 (1933).
(21) Eigen, M., and Wicke, E., *J. Phys. Chem.*, **58**, 702 (1954); Wicke, E., and Eigen, M., *Z. Electrochem.*, **57**, 319 (1953).
(22) Ackermann, Th., *Discussions Faraday Soc.*, **24**, 180 (1957).
(23) Glueckauf, E., *Trans. Faraday Soc.*, **51**, 1235 (1955).
(24) Stokes, R. H., and Robinson, R. A., *J. Am. Chem. Soc.*, **70**, 1870 (1948).
(25) Eigen, M., and Wicke, E., *Z. Electrochem.*, **55**, 354 (1951).
(26) Eucken, A., *Z. Electrochem.*, **51**, 6 (1948).
(27) Eigen, M., *Proc. Roy. Soc.*, **247A**, 505 (1958).
(28) Conway, B. E., Bockris, J. O'M., and Linton, H., *J. Chem. Phys.*, **24**, 834 (1956).
(29) Samoilov, O. Ya., *Discussions Faraday Soc.*, **24**, 141 (1957).
(30) Whitney, D. C., and Diamond, R. M., *J. Phys. Chem.*, **67**, 209 (1963).
(31) Marcus, Y., *Chem. Rev.*, **63**, 139 (1963).
(32) Beckey, H. D., *Z. Naturforsch.*, **14A**, 712 (1959); **15A**, 822 (1960).
(33) Knewstubb, P. F., and Tickner, A. W., *J. Chem. Phys.*, **38**, 464 (1963).
(34) Scatchard, G., *J. Phys. Chem.*, **58**, 713 (1954).
(35) (*a*) Frank, H. S., and Tsao, M. S., *Ann. Rev. Phys. Chem.*, **5**, 61–8 (1954); and (*b*) Redlich, O., and Jones, A. C., *Ann. Rev. Phys. Chem.*, **6**, 72, 78 (1955).
(36) Frank and Tsao, *op. cit.*, p. 68.

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Magnetic Stirrer

Instrument for the freshman laboratory

We have found it possible to mass produce a simple version of the magnetic stirrer. Usually the item readily available from commercial sources is unnecessarily sophisticated and costly.

The magnetic stirrer, almost indispensable for experiments in *p*H measurements, reaction rates, and distillations, is constructed entirely of new components obtained on the market at a cost of well under ten dollars and may be assembled by the students in about 20 min. The list of parts and the figure show the simplicity of this instrument. Students are encouraged to remove the snap cover in order to examine the operation of the stirrer. A degree of familiarity with the components of an instrument not only is of instructional value, but it encourages better cooperation on the part of the student to help in maintenance.

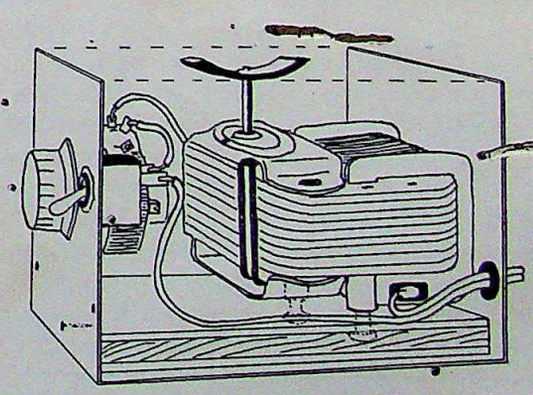
Conventional stirring bars may be used, but the student is encouraged to make his own by sealing an iron nail into glass tubing. An adequate supply of very inexpensive stirring bars is also available by cutting off a small section of a barium ferrite plastic bar. These are ideally suited to potentiometric titrations with the glass electrode because their small size greatly reduces the problem of breakage of the glass electrode.

Editor's Note: Probably readers who have had the experience of similar demands on ingenuity to replace funds will be able to contribute to a series of articles on this theme. We solicit only descriptions of instruments proven to be satisfactory by laboratory use.

Parts List

Shaded pole motor, 9 watt; Model DYAB, Barber-Coleman Co., Rockford, Illinois.	$2.89
Arc horseshoe Alnico 5 magnet, No. 5U50B, General Electric Co.	1.00
Rheostat, 25 watt, 2000 ohm; Radio Supply Outlet.	2.55
Minibox, Aluminum, 3 × 4 × 5, Radio Supply Outlet.	.77
Switch, SPST; Radio Supply Outlet.	.37
Grommet, 18-2 appliance cord, cord cap, epoxy cement, $^3/_8$-in. plywood blocks.	.35
Barium ferrite plastic rod; Edmund Scientific Co., Barrington N. J. (makes about 50 stirring bars).	1.00

Prices are for each in lots of 24 items.



Magnetic stirrer.

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National Bureau of Standards Values for Physical Constants

A new, consistent set of values has been recommended by the Committee on Fundamental Constants of the National Academy of Sciences-National Research Council. The National Bureau of Standards has adopted these values for use in all NBS publications. The tables below were taken from the October, 1963 NBS Technical News Bulletin. Further information is available from the NBS office of Technical Information, Washington, D.C. 20234.

Defined values and equivalents

Meter	(m)	1 650 763.73 wavelengths in vacuo of the unperturbed transition $2p_{10} - 5d_5$ in ^{86}Kr
Kilogram	(kg)	mass of the international kilogram at Sèvres, France
Second	(s)	1/31 556 925.974 7 of the tropical year at 12^h ET, 0 January 1900
Degree Kelvin	(°K)	defined in the thermodynamic scale by assigning 273.16 °K to the triple point of water (freezing point, 273.15 °K = 0°C)
Unified atomic mass unit	(u)	1/12 the mass of an atom of the ^{12}C nuclide
Mole	(mol)	amount of substance containing the same number of atoms as 12 g of pure ^{12}C
Standard acceleration of free fall	(g_n)	9.806 65 m s^{-2}, 980.665 cm s^{-2}
Normal atmospheric pressure	(atm)	101 325 N m^{-2}, 1 013 250 dyn cm^{-2}
Thermochemical calorie	(cal_{th})	4.1840 J, 4.1840×10^7 erg
International Steam Table calorie	(cal_{IT})	4.1868 J, 4.1868×10^7 erg
Liter	(l)	0.001 000 028 m^3, 1 000.028 cm^3 (recommended by CIPM, 1950)
Inch	(in.)	0.0254 m, 2.54 cm
Pound (avdp.)	(lb)	0.453 592 37 kg, 453.592 37 g

Adjusted values of constants

Constant	Symbol	Value	Est. ‡ error limit	Unit: Système International (MKSA)		Unit: Centimeter-gram-second (CGS)	
Speed of light in vacuum	c	2.997925	3	$\times 10^8$	m s^{-1}	$\times 10^{10}$	cm s^{-1}
Elementary charge	e	1.60210	7	10^{-19}	C	10^{-20}	$cm^{1/2}g^{1/2}$ *
		4.80298	20	...	...	10^{-10}	$cm^{3/2}g^{1/2}s^{-1}$ †
Avogadro constant	N_A	6.02252	28	10^{23}	mol^{-1}	10^{23}	mol^{-1}
Electron rest mass	m_e	9.1091	4	10^{-31}	kg	10^{-28}	g
		5.48597	9	10^{-4}	u	10^{-4}	u
Proton rest mass	m_p	1.67252	8	10^{-27}	kg	10^{-24}	g
		1.00727663	24	10^0	u	10^0	u
Neutron rest mass	m_n	1.67482	8	10^{-27}	kg	10^{-24}	g
		1.0086654	13	10^0	u	10^0	u
Faraday constant	F	9.64870	16	10^4	C mol^{-1}	10^3	$cm^{1/2}g^{1/2}mol^{-1}$ *
		2.89261	5	...	...	10^{14}	$cm^{3/2}g^{1/2}s^{-1}mol^{-1}$ †
Planck constant	h	6.6256	5	10^{-34}	J s	10^{-27}	erg s
	$\hbar$	1.05450	7	10^{-34}	J s	10^{-27}	erg s
Gas constant	R	8.3143	12	10^0	J °K^{-1} mol^{-1}	10^7	erg °K^{-1} mol^{-1}
Normal volume perfect gas	V_0	2.24136	30	10^{-2}	m^3 mol^{-1}	10^4	cm^3 mol^{-1}
Boltzmann constant	k	1.38054	18	10^{-23}	J $°K^{-1}$	10^{-16}	erg $°K^{-1}$
Charge to mass ratio for electron	e/m_e	1.758796	19	10^{11}	C kg^{-1}	10^7	$cm^{1/2}g^{-1/2}$ *
		5.27274	6	...	...	10^{17}	$cm^{3/2}g^{-1/2}s^{-1}$ †
Quantum-charge ratio	h/e	4.13556	12	10^{-15}	J s C^{-1}	10^{-7}	$cm^{3/2}g^{1/2}s^{-1}$ *
		1.37947	4	...	...	10^{-17}	$cm^{1/2}g^{1/2}$ †
Rydberg constant	R_∞	1.0973731	3	10^7	m^{-1}	10^5	cm^{-1}
Bohr radius	a_0	5.29167	7	10^{-11}	m	10^{-9}	cm
Electron radius	r_e	2.81777	11	10^{-15}	m	10^{-13}	cm
	r_e^2	7.9398	6	10^{-30}	m^2	10^{-26}	cm^2
Gravitational constant	G	6.670	15	10^{-11}	N m^2 kg^{-2}	10^{-8}	dyn cm^2 g^{-2}

‡ Based on 3 std. dev. applied to last digits in preceding column. * Electromagnetic system. † Electrostatic system. C—Coulomb J—joule N—newton.

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Clathrates: Compounds in Cages

There is a special type of inclusion compound whose properties are not well known but which are very interesting and may prove more useful than one might have anticipated. These are the clathrate compounds. About fifteen years ago H. M. Powell at Oxford University first identified these cage-like molecular compounds which he aptly named "Clathrates," from the Latin word, *clathratus*, which means enclosed behind bars (*1*). His work was anticipated by Mylius in 1886, but the earlier work went largely unnoticed. Essentially clathrates are a type of inclusion compound in which one molecule, or a framework made up of one kind of molecule, completely encloses a second. The second molecule is thereby prevented from escaping even though it is not chemically bonded to the first.

The hydroquinone cage structure, one of the first intensively studied, is frequently used to illustrate a true clathrate compound. Crystalline structure studies have shown it to have the fairly complicated pattern shown in Figure 1. The small open hexagons represent the oxygen atoms of hydroquinone molecules hydrogen-bonded together in groups of six to form a plane hexagon. The hydroquinone molecules are not shown but

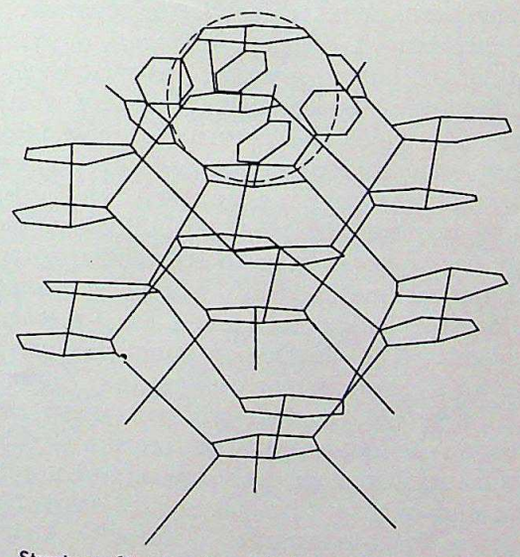

Figure 1. Structure of hydroquinone clathrate. The circle in the top shows one cage (D. E. Palin and H. M. Powell, *Nature*, **156**, 335 (1945)).

the HO · · · OH axes of the molecules are shown by the sloping lines connecting the hexagons at different levels. When one cage structure is formed, simultaneously a second identical cage structure will interpenetrate it and be displaced vertically halfway between the top and the bottom of the first hexagon. In this way, hydroquinone forms a clathrate with itself, and at the same time the double interpenetrated framework will contain a cavity in which smaller molecules may be trapped. This cavity is roughly spherical and is about 4 Å in diameter.

X-ray crystal structure determinations have shown that the large hydroquinone cage in which different molecules are trapped is made up of three hydroquinone molecules for each trapped molecule. A simplified structure of the hydroquinone clathrate

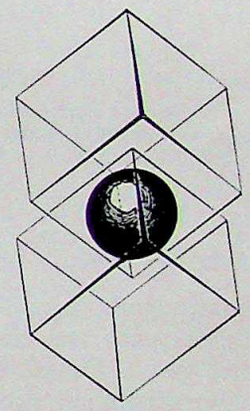

Figure 2. Schematic representation of a Clathrate cage, (D. E. Palin and H. M. Powell, *J. Chem. Soc.*, **1948**, 818).

compound is shown in Figure 2. Compounds of the general formula, $3C_6H_4(OH)_2 \cdot M$ are common. The hydroquinone cage is called "the host." It has an amazing flexibility which has been compared to a lattice. This flexibility enables it to elongate in order to entertain long molecules when necessary as is shown in the simplified diagram, Figure 3. The "hinge" effect which makes the elongation possible is attributed to that portion of the structure shown in Figure 4. The elongation is noted in molecules like the hydroquinone-methyl cyanide clathrate compound whose framework is more distorted than that of any other known hydroquinone clathrate. Powell suggested that this distortion is the result of both a slight extension and a puckering of the hexagon of hydrogen bonds through which the quinol molecules are linked. Measurements of angle θ, shown in the diagram, vary when certain larger (longer) molecules are enclosed.

Inorganic as well as organic host structures are known. For example, an ammoniacal nickel cyanide solution will, on crystallization in the presence of benzene and like compounds, enclose the organic molecule.[1] As in all clathrate compounds, the cage structure is re-

[1] Editor's Note: The reader is referred to the article by V. M. Bhatnagar in This Journal 40, 646 (1963) for a more detailed discussion of this compound and its structure.

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ferred to as the "host," while the entrapped atom or molecule is known as the "guest." Size, shape, location, and position of the guest at the time of crystallization, are all contributing factors to the formation or lack of formation of clathrates.

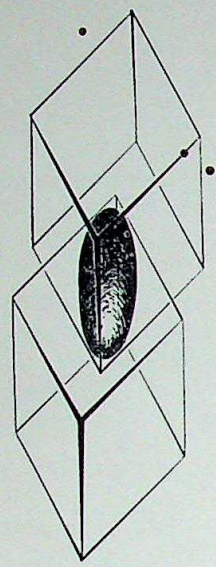

Figure 3. Schematic representation of the extension of a cage in one direction and contraction in the oppsite direction caused by the enclosure of a "long" guest molecule, (D. E. Palin and H. M. Powell, *J. Chem. Soc.*, 1948, 818).

Uses and Applications

These unusual compounds may be used to *store inert gases* (*2*). In his paper on the clathrate compounds of the inert gases, Powell showed that the volume of crystalline substance, for example of the hydroquinone-argon clathrate $3C_6H_4(OH)_2 \cdot Ar$ which would theoretically have a volume of approximately 260 ml, would contain 1 mole of argon. This same quantity, that is, 1 mole of pure argon gas, at 15°C would have a pressure of 91 atmospheres if it were to occupy the same volume when not clathrated! A more dramatic demonstration of what has occurred here is observed when we compare the volume of the clathrate compound, 260 ml, with the volume 25,100 ml which 1 mole of argon would occupy as a gas at this temperature and pressure.

It would seem that clathration of the inert gases for purposes of storage would eliminate both pressure and volume problems. It is well to mention here that when Powell prepared the inert gas clathrates he usually worked with gases under pressures up to 40 atmospheres and consequently obtained clathrates in which the cavities were not all filled with the gas atoms. The argon clathrate which he prepared has the formula $3C_6H_4(OH)_2 \cdot 0.8Ar$. The argon found in it would be equivalent to pure argon of the same quantity at a pressure of 73 atmospheres. Presumably working under higher pressures to prepare the clathrate would produce clathrates containing stoichiometrical quantities of argon, that is, with all available cavities filled. In most cases the gas may be liberated from the clathrate compound by heating it or by dissolving it. The formation of such crystalline gas-containing molecules introduces the intriguing possibility of using them to release gases in some hitherto inaccessible places and under previously disadvantageous conditions.

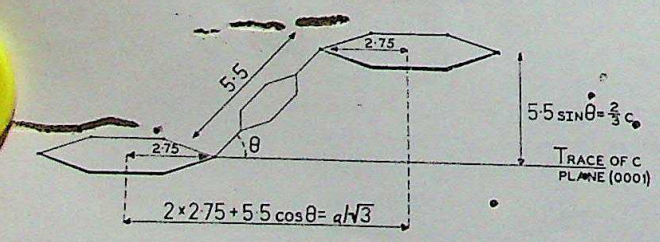

Figure 4. One hydroquinone molecule is shown with its oxygen-oxygen axis inclined at an angle *theta* to the 001 plane. The two hexagons of hydrogen-bonded OH groups through which this molecule is linked to the rest of the structure are drawn in, and the way in which the angle *theta* may be related to either the a or the c dimension of the unit cell is indicated. The distances marked are in angstrom units. The hinge effect is obtained by variations in the angle *theta* (H. M. Powell, *J. Chem. Soc.*, 1948, 817).

Clathrates have been used in the *separation of mixtures*. Benzene has been essentially freed of thiophene by the formation of the clathrate of benzene previously described (*3*). The benzene is preferentially trapped in the monoammine nickel(II) cyanide cage. There is no obvious manner in which the benzene molecule may be linked to the nickel cyanide complex and the structure shown has been verified by X-ray analysis methods. Since this work was first reported a method has been devised which may well become a valuable synthetic tool for the organic chemist. The clathrate of benzene-monoammine nickel(II) cyanide has been subjected to neutron irradiation and the ^{14}C benzene has been subsequently recovered for use as a labeled compound (*4*).

The *separation of isomers* by clathration (*5*) has met with notable success. In 1957, *Chemical and Engineering News* carried a report of the work being done in the research laboratories of Union Oil where Schaeffer and Dorsey had prepared over 100 different complexes which could be used to separate many chemicals which have been considered difficult to separate. They applied methods of selective clathration to various processes or production streams. At that time, tetra-(4-methylpyridino) nickel dithiocyanate was given as one compound which had been used successfully on a laboratory scale to recover *p*-xylene or *p*-cymene to make terephthalic acid. Even then, 1957, *p*-xylene production was running about 80 million pounds per year and was expected to go to 100 million pounds per year. Practical methods of separating isomers of certain organic compounds, such as *p*-xylene, were being sought. The clathration complexes are highly selective for a given isomer or isomers. A year later (1958), Union Oil research workers again reported their work on clathration going on record with the statement, "Clathrating techniques appear to have definite economic and quality advantages over other methods of purifying hard-to-separate isomers." At a more recent ACS meeting in St. Louis, Radzitsky discussed a further extension of the work of Schaeffer (*6*). His report was on the separation of hard-to-separate aromatic mixtures which is being carried out in Belgium. In this paper he described the use of new Werner complexes of the general formula $[Ni(SCN)_2$ (primary substituted benzylamine)$_4]$.

Mixtures of the inert gases have been separated. Argon has been separated from neon by adjusting the pressure conditions for clathration in such a manner that the

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hydroquinone-argon forms but the hydroquinone-neon does not. Krypton and xenon, both form compounds with hydroquinone but xenon, being more soluble, will more readily undergo clathration than krypton. Usually a mixture of about 3 parts xenon to 1 part krypton, by volume, will be liberated from crystals which have been formed by subjection of a hydroquinone solution to equal volumes of a krypton-zenon mixture under pressure.

The *resolution of racemic mixtures* by inclusion has been extensively studied by a number of workers. The first reported resolution was that of Windaus and his co-workers (*7*). Using the solubility differences of the complexes of digitonin with *d*- and *l*- forms of α-terpineol and tetrahydro-β-naphthol, Windaus effected an almost complete resolution of *dl*-α-terpineol and *dl*-tetrahydro-β-naphthol. Powell and his co-workers alone have reported the resolution of over fifty guest molecules including alkanes, alkyl halides, alcohols, esters, ketones, ethers, and polymethylene dihalides (*8*).

Relatively recently, in a biology symposium which was held at MIT on the "Fast Fundamental Transfer Processes in Aqueous Bimolecular Systems," it was reported that they now have employed the hydrates of certain hydrocarbons, etc.—which are clathrate compounds—for examination by electron microscopy and electron diffraction as a basis for direct studies of biological systems in their native hydrated states (*9*).

In 1960, two workers at the Polish Academy of Science in Warsaw described the application of clathrate compounds in chromatography and said that these compounds afford an excellent method for the separation of isomers (*10*). They claimed the quantitative separation of ortho and other isomers of isomeric nitrophenols, nitroanilines, chloronitrobenzenes, and nitrotoluenes (*11*).

Certainly one of the most unusual uses is that devised by Chleck and Ziegler of Tracerlab. Their first report was basically a description of a new way of handling ^{85}Kr. This isotope of krypton provides a safe and useful source of radiation (*12*). Its gaseous nature is its only drawback. To overcome this obstacle a technique was developed which consisted of trapping the krypton in a three-dimensional organic crystalline cage, that is, clathrating it. According to Chleck and Ziegler, the hydroquinone-^{85}Kr clathrate which they prepared is among the safest forms of radioactivity. ^{85}Kr is virtually a pure emitter (10.3-yr, 0.67-mev β) and does not require heavy shielding for safe handling. When released from the clathrate cage, it is rapidly diluted and carried away by the surrounding atmosphere. Even if accidentally inhaled, ^{85}Kr is incapable of being metabolized or absorbed by the body. In addition, its decay product is a stable nuclide; therefore, the radiation is only that originating from krypton. Dissolution of the clathrate provides a controlled release of the gaseous krypton. The adaptability of the clathrate is further enhanced by the fact that it can be powdered into grains of salt or sugar crystal size which makes it very manageable.

Even a cursory study of clathrates and their uses will provide convincing evidence that this small segment of inclusion compounds is a versatile one. Not long ago Pauling reported studies which indicate that anesthesia may be attributed to the formation in the brain of minute hydrate crystals of the clathrate type (*13*). The hydrocarbon-rate method, recently developed, has been applied to the conversion of saline water to fresh water (*14*). The use of an α-dextrin clathrate of carbon dioxide as a baking powder had been patented (*15*). It would be difficult to imagine an area in which there are more avenues for investigation than that of the structures of molecules in biological systems. Even the degree of inclusion, whether in part, as in channel inclusion, or *in toto*, as in clathrates, or by some type of bonding, may prove to be the key to the ultimate understanding of their activities. In view of the uses to which they have already been put it would seem likely that a great deal more will be heard about clathrates in the near future (*16*).

Literature Cited

(1) Powell, H. M., *J. Chem. Soc.*, **1948**, 61.
(2) Brit. Oxygen Co. Ltd., and Powell, H. M., British patent 678,312 (Sept. 3, 1952); *C. A.*, **47**, 3532a(1953).
(3) Dacey, J. R., Smelko, J. F., and Young, D. M., *J. Phys. Chem.*, **59**, 1058 (1955).
(4) Wolf, A. P., Redvanly, C. S., and Anderson, R. C., *Nature*, **176**, 831 (1955).
(5) Schaeffer, W. D., Dorsey, W. S., Skinner, D. S., and Christian, C. G., *J. Am. Chem. Soc.*, **79**, 5870 (1957).
(6) Radzitsky, P. de, and Hanotier, J., "Abstracts of Papers," 139th Meeting, ACS, St. Louis, Mo., Mar. 1961, p. 4Q.
(7) Windaus, A., Klänhard, F., and Weinhold, R., *Z. physiol. Chem.*, **126**, 308 (1923).
(8) Lawton, D., and Powell, H. M., *J. Chem. Soc.*, **1958**, 2339.
(9) Fernández-Morán, Humberto, "Fast Fundamental Transfer Processes in Aqueous Biomolecular Systems," Dept. of Biol., Cambridge, Massachusetts Institute of Technology, 1960, p. 33.
(10) Kemula, W., *Roczniki Chem.*, **26**, 261(1952); *Prezemysl Chem.*, **33**, 453 (1954).
(11) Kemula, W., and Sybilska, D., *Nature*, **185**, 237 (1960).
(12) Chleck, D. J., and Ziegler, C. A., *Intern. J. Appl. Radiation Isotopes*, **7**, 141 (1959).
(13) Pauling, L., *Science*, **134**, 15 (1961).
(14) *Chem. Eng. News*, **39**, (1), 37 (1961).
(15) Schlenk H., Sand, D. M., and Tillotson, J. A., *J. Am. Chem. Soc.*, **77**, 3587(1955); U. S. patent 2,827,452 (Mar. 18, 1958).
(16) Hagan, Sister Martinette, "Clathrate Inclusion Compounds," Reinhold, New York, 1962.

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Punjab University
Chandigarh, Punjab, India

Benzene Clathrate

A clathrate may be described as a single-phased solid consisting of two distinct components: the host and the guest. The guest is retained in closed cavities or cages provided by the crystalline structure of the host. Generally, a cage and its enclosed molecule or molecules are taken as a unit cell.

In 1897, Hofmann and Küspert (*1*) published a paper in which they stated that when benzene is added to a solution of nickel cyanide in aqueous ammonia and containing acetic acid, a precipitate of the composition $[Ni(CN)_2 \cdot NH_3 \cdot C_6H_6]$ is formed. Other examples of these molecular compounds are those formed between nickel cyanide-ammonia complex, $Ni(CN)_2 \cdot NH_3$, and molecules of aniline, benzene, phenol (*2*), and pyridine, furan, pyrrole, and thiophene (*3*). The maximum composition formula for this series of monoammine-nickel(II) cyanide clathrates is $[Ni(CN)_2 \cdot NH_3 \cdot M]$, where M is the organic molecules previously mentioned. Cambi, *et al.* (*4*) made careful magnetochemical investigations on nickel cyanide and complex derivatives. They measured the magnetic susceptibility of $[Ni(CN)_2 \cdot NH_3 \cdot C_6H_6]$ and gave the value of 11.04. The magnetic susceptibility of this clathrate was also measured by Janes (*5*) over a temperature range from 82.5 to 296°K. Although he took into account the effect of a crystal field, he found that there was no possibility of the theoretical formula for molar susceptibilities agreeing with the experimental data, because the magnetic moment of the nickel atom equal to 2.27 Bohr magnetons at 300.6°K was subnormal, i.e., smaller than the spin-only value, 2.83 Bohr magnetons. He tentatively suggested an explanation in terms of an assumption that there is a predominantly rhombic or perhaps axial crystal field, which quenches not only the orbital but also a part of the spin contribution to the magnetic moment. Janes tacitly assumed that all the nickel atoms in the compound are equivalent to one another.

A single crystal X-ray investigation was undertaken on the benzene clathrate (*6, 7*), and the large distance between the carbon atoms of benzene and the atoms of the caging material was interpreted to mean that the organic molecules are not bonded but are simply trapped in the crystal lattice. The crystal structure of this clathrate is an extended two dimensional flat network of alternating nickel and cyanide groups. In the presence of the guest component, the complex crystallizes in planar arrays of nickel cyanide with the ammonia molecules, bonded to nickel atoms, projected above and below each other. Each guest molecule is located in a cavity bound by two planes of nickel cyanide and by vertically aligned pairs of ammonia molecules (Fig. 1).

The merely space-filling part played by benzene is evidenced by the fact that other molecules of comparable volume can replace it; these are as follows (molecular volumes at 15°C in parentheses): aniline (90.5), phenol (88.8), pyridine (80.0), pyrrole (69.3), thiophene (78.5), and furan (72.0). All these compounds are included in the ammino-nickel cyanide structure to yield crystalline products of compositions corresponding to and properties almost identical with that formed by benzene [molecular volume (88.6)]. The nickel complex is, however, quite indifferent to the following larger molecules: toluene (105.6), nitrobenzene (103.6), fluoro-, chloro-, bromo-, and iodobenzene (93.8–110), toluidine (107.0), cresol (102.0), and naphthalene (111.0).

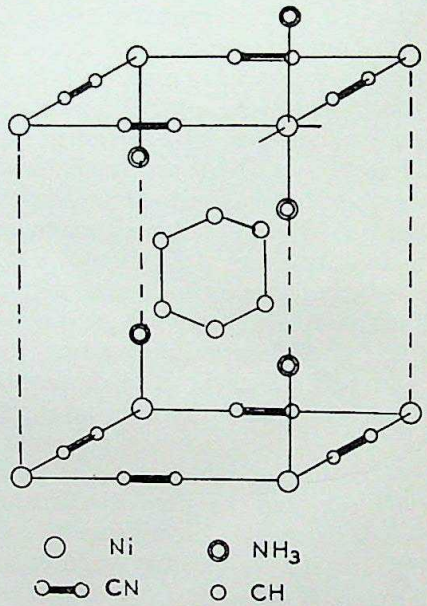

Figure 1. Cage lattice structure of benzene, ammonia, and nickel cyanide, $[Ni(CN)_2 \cdot NH_3 \cdot C_6H_6]$.

It is interesting to compare (*8*) the packing of benzene when caged in the nickel complex with that found in the solid pure hydrocarbon, which crystallizes in the orthorhombic system, with a unit cell of dimensions: a = 7.44 Å, b = 9.65 Å, and c = 6.81 Å (*9*). The flat rings are arranged in parallel layers, with the plane of the ring perpendicular to the layer planes; succeeding layers are identical but each is translated by a distance $^1/_2\ a$ relative to the neighboring plane. The closest approach of carbon atoms is between 3.8 and 3.9 Å. The similar plan for the caged structure, in which the cage imposes the higher tetragonal symmetry on the benzene, indicates that benzene molecules are closely packed, the closest approach, 3.4–3.5 Å.

The preparation of benzene clathrate has been described by Hofmann, *et al.* (*1, 2*), Palmer (*10*), and Bhatnagar and Fujiwara (*11*).

In 1955, Leicester and Bradley (*12*) reported that certain biphenyls (biphenyl, 4-amino biphenyl, and 4-hydroxy biphenyl) co-crystallize with monoammino-nickel (*11*) cyanide as solids with a characteristic

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formula of $2[Ni(NH_3)]^{2+} \cdot 2CN^-M$. However, 2-amino diphenyl and 2-2′-dihydroxy diphenyl do not form complexes under similar conditions and neither does stilbene. Baur and Schwarzenbach (*13*) synthesized a few new clathrates from double cyanides, $M\,Ni(CN)_4$, where M stands for Cu^{2+}, Cd^{2+}, or Zn^{2+}. Examples of synthesized and examined clathrates are $[Cu(NH_3)_2Ni(CN)_4 \cdot C_6H_6]$, $[Cd(NH_3)_2Ni(CN)_4 \cdot {}^3/_2C_6H_6]$, and $[Zn\,Ni(CN)_4 \cdot {}^1/_2C_6H_6]$. They are suggested to be similar to $[Ni(CN)_2 \cdot NH_3 \cdot C_6H_6]$.

A process for the recovery of benzene by selective clathration was patented by Jones and Fay (*14*). The invention related to a process and apparatus for the recovery of benzene from hydrocarbon stocks and, more particularly, to a cyclic process adapted for continuous operation for the recovery of benzene of high purity from low benzene hydrocarbon stocks, such as refinery naphthas. The process comprised continuously blending a stream of the stock with a stream of nickel cyanide-ammonia; conducting the blend to a homogenizer and homogenizing the blend to form a solid clathrate compound with benzene conducting the resultant slurry to a centrifugal separator, and centrifugally separating the solid clathrate compound from the stock; conducting the clathrate compound to a stripper and countercurrently flowing the slurry against a stream of steam and ammonia to decompose the clathrate compound into benzene and nickel cyanide-ammonia; recovering benzene, steam, and ammonia at the top of the stripper; drawing off recovered nickel cyanide-ammonia at the bottom of the stripper; and recycling the nickel cyanide-ammonia.

Aynsley, *et al.* (*15*) examined the physical properties of $[Ni(CN)_2 \cdot NH_3 \cdot C_6H_6]$, and contrary to previous assertions (*7*, *8*), they found that the benzene could be removed *in vacuo* (without removal of ammonia), slowly at room temperature and rapidly (50% in 1–3 hours) at 40–60°C. Up to at least 80% removal of benzene the decomposition was of zero order, varying in rate from sample to sample. They presumed that liberation of benzene was accompanied by a partial collapse of the lattice, which is then not wholly available for reabsorption of benzene. Discussing the two benzene frequencies at 1573 and 1166 cm^{-1}, they stated that due to relaxation of the selection rules, these frequencies appeared in liquid benzene at 1587 and 1179 cm^{-1}, but not in the benzene crystals. They expected the same restriction to be applied to benzene in the clathrate compound, and yet the band at 1166 cm^{-1} was the strongest band in the region 4000–650 cm^{-1}. Spectroscopic studies on benzene clathrate have been completed by Bhatnagar and Cole (*16*).

Kondo and Kubo (*17*) measured the magnetic susceptibilities of dicyanoamminenickel (*11*), and the clathrate compounds thereof with benzene and pyridine at room temperature and the effective magnetic moments per one nickel atom were calculated. These moments, which were approximately equal to 2.2 Bohr magnetons, were explained by the presence of equal numbers of nickel atoms having no unpaired electrons. The former have four ligands in square coordination resulting from dsp^2 hybridization, while the latter are coordinated with six ligands in octahedral coordination involving d^2sp^3 hybridization of the central nickel atoms. Drago, *et al.* (*18*) explained that since planar nickel (*11*) atoms are usually diamagnetic, it is possible that the benzene, instead of being trapped in the crystal lattice, was interacting with the nickel to produce a paramagnetic tetragonal atom. They redetermined the magnetic data and examined the infrared spectra to provide additional structural information. A structure containing trapped benzene, compatible both with the X-ray work and with the magnetic moment of 2.1 Bohr magnetons obtained in their study, was proposed. The X-ray powder diffraction pattern of decomposed benzene clathrate (*19*), electron paramagnetic resonance (*11*), and proton magnetic resonance spectra (*20*) have been described.

Evans, *et al.* (*21*) stated that if the benzene clathrate were formed from thiophene-free but otherwise impure benzene, the benzene recovered on the destruction of the compound should be quite free from the saturated hydrocarbons which are otherwise very difficult to remove. They found that by this method benzene can be obtained from impure material in good yield and of a purity as good as, if not superior to, that of samples produced by prolonged fractionation in a very efficient still, or by the tedious and wasteful process of fractional crystallization and fusion. For example, in one simple operation benzene was separated from other contaminating hydrocarbons and produced in 99.992% purity by forming the clathrate compound with nickel cyanide-ammonia and then releasing the caged benzene by dissolving the crystals.

I wish to thank Prof. N. S. Bayliss and Dr. A. R. H. Cole, University of Western Australia; Prof. R. C. Paul, Punjab University; and Council of Scientific and Industrial Research, India.

Literature Cited

(1) Hofmann, K. A., and Küspert, F. Z. *anorg. Chem.*, **15**, 204 (1897).
(2) Hofmann, K. A., and Höchtlen, F., *Chem. Ber.*, **36**, 1149 (1903).
(3) Hofmann, K. A., and Arnoldi, H., *Chem. Ber.*, **39**, 339 (1906).
(4) Cambi, L., Cagnasso, A., and Tremolada, E., *Gazz. Chim. Ital.*, **64**, 758 (1934).
(5) Janes, R. B., *Phys. Rev.*, **48**, 78 (1935).
(6) Powell, H. M., and Rayner, J. H., *Nature*, **163**, 566 (1949).
(7) Rayner, J. H., and Powell, H. M., *J. Chem Soc.*, **1952**, 319.
(8) Palmer, W. G., "Experimental Inorganic Chemistry," Cambridge University Press, London, **1954**, p. 518.
(9) Cox, E. G., *Proc. Roy. Soc.*, **A135**, 491 (1932).
(10) Palmer, W. G., *op. cit.*, p. 561.
(11) Bhatnagar, V. M., and Fujiwara, S., *Chem. Ind.* (*London*), **1962**, 1471.
(12) Leicester, J., and Bradley, J. K., *Chem. Ind.*, **1955**, 1449.
(13) Baur, R., and Schwarzenbach, G., *Helv. Chim. Acta*, **43**, 842 (1960).
(14) Jones, A. L., and Fay, P. S., (to Standard Oil Co., Ohio), U. S. 2,732,413, January 24, 1956. *C. A.*, **50**, 10392^f (1956).
(15) Aynsley, E. E., Campbell, W. A., and Dodd, R. E., *Proc. Chem. Soc.*, **1957**, 210.
(16) Bhatnagar, V. M., and Cole, A. R. H., Unpublished work.
(17) Kondo, M. and Kubo, M., *J. Am. Chem. Soc.*, **61**, 1648 (1957).
(18) Drago, R. S., Kwon, J. T., and Archer, R. D., *J. Am. Chem. Soc.* **80**, 2667 (1958).
(19) Bhatnagar, V. M., *J. Indian Chem. Soc.*, **39**, 667 (1962).
(20) Nakajima, H., Bhatnagar, V. M., and Cole, A. R. H., *J. Phys. Soc. Japan*, **17**, 1194 (1962).
(21) Evans, R. F., Ormrod, O., Goalby, B. B., and Staveley, L. A. K., *J. Chem. Soc.*, **1950**, 3346.

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Duhem and the Gibbs-Duhem Equation

In recent issues of THIS JOURNAL, the Gibbs-Duhem equation has been the subject of numerous comments (e.g., J. CHEM. EDUC., **39**, 527 (1962); *ibid.*, **40**, 225–8 (1963)). However, the role played by Duhem has not been mentioned.

I am not as yet sure when or by whom Duhem's name was added to the equation. But it appears that Duhem was the first to use Euler's theorem explicitly to prove the Gibbs–Duhem equation. The first references appear in his book "Le Potentiel Thermodynamique"[1] which was published in 1886.[2] On pages 32–3 Duhem applies Euler's theorem to a two-component system, and on pages 141–2 he discusses the general case.

This whole subject is also given in his "Mécanique Chimique,"[3] which while not rare is usually found only in large libraries. The presentation is so clear and concise that I believe a translation of it using current notation would be interesting and informative.

Some Properties of Homogeneous Functions

It is said, with Euler, that a function $F(x_1, \ldots, x_n)$ of n variables, $x_1, \ldots, x_n$ is *homogeneous of degree m* with respect to these variables if the identity

$$F(\lambda x_1, \ldots, \lambda x_n) = \lambda^m F(x_1, \ldots, x_n)$$

holds for arbitrary $x_1, \ldots, x_n$, and λ.

Theorem I. *If a function is homogeneous of degree m with respect to the variables $x_1, \ldots, x_n$, its partial derivatives with respect to each of these variables are homogeneous functions of degree $(m - 1)$ in these same variables.*

The identities

$$F(\lambda x_1, \ldots, \lambda x_n) = \lambda^m F(x_1, \ldots, x_n)$$

$$F[\lambda(x_1 + \Delta x_1), \lambda x_2, \ldots, \lambda x_n] = \lambda^m F(x_1 + \Delta x_1, x_2, \ldots, x_n)$$

resulting from the previous definition yield

$$\frac{F[\lambda(x_1 + \Delta x_1), \lambda x_2, \ldots, \lambda x_n] - F(\lambda x_1, \lambda x_2, \ldots \lambda x_n)}{\lambda \Delta x_1} = \frac{\lambda^{m-1}[F(x_1 + \Delta x_1, x_2, \ldots, x_n) - F(x_1, x_2, \ldots, x_n)]}{\Delta x_1}$$

or, passing to the limit as Δx_1 tends toward zero

$$\frac{\partial F(\lambda x_1, \lambda x_2, \ldots, \lambda x_n)}{\partial(\lambda x_1)} = \lambda^{m-1} \frac{\partial F(x_1, x_2, \ldots, x_n)}{\partial x_1}$$

which proves the theorem.

Theorem II (Euler's Theorem). *If the function $F(x_1, \ldots, x_n)$ is homogeneous of degree m with respect to the variables $x_1, \ldots, x_n$, then one has the identity*

$$x_1 \frac{\partial F}{\partial x_1} + x_2 \frac{\partial F}{\partial x_2} + \ldots + x_n \frac{\partial F}{\partial x_n} = mF$$

By hypothesis, one has the identity

$$F(\lambda x_1, \ldots, \lambda x_n) = \lambda^m F(x, \ldots, x_n)$$

The derivatives with respect to λ of each member of this identity must also be identical with one another

$$x_1 \frac{\partial F(\lambda x_1, \ldots, \lambda x_n)}{\partial(\lambda x_1)} + \ldots + x_n \frac{\partial F(\lambda x_1, \ldots, \lambda x_n)}{\partial(\lambda x_n)} = m\lambda^{m-1} F(x_1, \ldots, x_n)$$

If the various terms of the first member are transformed by means of Theorem I and the common factor λ^{m-1} is suppressed on both sides, one finds the equality given in the theorem.

Gibbs Free Energy (Thermodynamic Potential) of a Homogeneous Solution

A homogeneous solution of fluids $1, \ldots, n$ at a constant pressure P and constant temperature T has a Gibbs free energy G which depends on the masses $m_1, \ldots, m_n$ of the fluids and on the pressure P and the temperature T:

$$G = G(m_1, \ldots, m_n, P, T)$$

At the same P and T, let us mix masses $\lambda m_1, \ldots, \lambda m_n$ of the fluids $1, \ldots, n$. We obtain a second solution, of the same nature as the preceding, but of mass λ times greater. If we neglect the forces that the various parts of a mixture exert on one another, we may attribute to the second solution a Gibbs free energy λ times greater than to the first. We will thus have for arbitrary λ

$$G(\lambda m_1, \ldots, \lambda m_n, P, T) = \lambda G(m_1, \ldots, m_n, P, T)$$

The Gibbs free energy of a homogeneous solution of n fluids is a homogeneous function of the first degree in the masses of the fluids.

Let us set

$$\frac{\partial G}{\partial m_1} = \bar{G}_1, \ldots, \frac{\partial G}{\partial m_n} = \bar{G}_n \qquad (1)$$

and apply Euler's theorem to the function G. We will have

$$G = m_1 \bar{G}_1 + \ldots + m_n \bar{G}_n \qquad (2)$$

It results from this formula that the functions $\bar{G}_1, \ldots, \bar{G}_n$ are quantities of the same type as the quotient of an energy or a work by a mass. Hence these are quantities of the same type as a potential function. We will call them *partial specific free energies of the constituents* $1, \ldots, n$ *in the solution* (thermodynamic potential functions).

In virtue of theorem I of the preceding paragraph, the functions $\bar{G}_1, \ldots, \bar{G}_n$ are homogeneous functions of degree zero in the variables $m_1, \ldots, m_n$. To each of these functions we apply Euler's theorem, and we will find the identities

$$m_1 \frac{\partial \bar{G}_1}{\partial m_1} + \ldots + m_n \frac{\partial \bar{G}_1}{\partial m_n} = 0$$

$$m_1 \frac{\partial \bar{G}_n}{\partial m_1} + \ldots + m_n \frac{\partial \bar{G}_n}{\partial m_n} = 0 \qquad (3)$$

The identities

$$\frac{\partial \bar{G}_i}{\partial m_j} = \frac{\partial \bar{G}_j}{\partial m_i}$$

This work was performed under the auspices of the U. S. Atomic Energy Commission.

[1] DUHEM, P., "Le Potentiel Thermodynamique et Ses Applications à La Mécanique Chimique et à L'Étude des Phénomènes Electriques," A. Hermann, Paris, 1886.

[2] It had actually been written in 1884 (when Duhem was 23) and submitted as a thesis at the Sorbonne. This thesis was refused through the influence of Marcelin Berthelot, who was still trying to support his erroneous maximum work principle.

[3] DUHEM, P., "Traité Elémentaire de la Mécanique Chimique Fondée sur la Thermodynamique," 4 volumes, A. Hermann, Paris, 1897–9, Vol. 3, pp. 1–4.

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which result from the definition of the functions $\bar{G}_1, \ldots, \bar{G}_n$ given by equation (1), permit the substitution of equations for equations (3).

$$m_1 \frac{\partial \bar{G}_1}{\partial m_1} + \ldots + m_n \frac{\partial \bar{G}_n}{\partial m_1} = 0$$

$$m_1 \frac{\partial \bar{G}_1}{\partial m_n} + \ldots + m_n \frac{\partial \bar{G}_n}{\partial m_n} = 0$$

Duhem was a great admirer of Gibbs, was his principal champion in France, and extended a number of Gibbs' ideas. It is altogether fitting that his name be appended to the Gibbs–Duhem equation.

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A classical electrostatic view of **Chemical Forces**

In the present paper, we shall attempt to review the different types of forces involved in the formation of chemical compounds, solids and liquids. In spite of the need of non-classical, quantum mechanical methods to achieve anything more accurate than the crudest qualitative calculations of the energies arising from the operation of these forces, it will be shown that, basically, they are all of a classical, electrostatic nature, and that the salient features of their operation can be understood from simple electrostatic considerations, even though these are utterly incapable of providing a satisfactory quantitative treatment.

These forces must explain the existence of the following types of matter: In the *solid state*, crystals may be classified into the following four extreme classifications, with various intermediates:

(1) Ionic crystals, consisting of an ordered lattice of ions.

(2) Molecular crystals, consisting of an orderly arrangement of neutral molecules.

(3) Extended lattice crystals, such as SiO_2, in which neither free ions, nor individual molecules can be identified.

(4) Metallic crystals, in which an orderly array of neutral atoms of one kind is held together in a manner approximating none of the other three classes.

In the *liquid state*, we must take account of:

(1) The cohesion of neutral molecules to form the disordered condensed phase.

(2) The various interactions between solvent and solute, as well as the interactions between like and dislike species in liquid mixtures.

In the *gas phase*, we note the existence of molecules, i.e., groups of atoms combined into and acting as a unit. The same problem arises for the molecules of the molecular crystal, for the entire extended lattice crystal, and for the molecules in the liquid state.

Simple Electrostatic Forces

We shall start with the interaction of two ions, of charge e_1 and e_2 at a distance r. The attractive Coulombic force between two such ions is

$$f = e_1 e_2 / r^2,$$

and depends on the distance through the inverse second power. This type of force leads to typical ionic bonds, as encountered in ionic crystals.

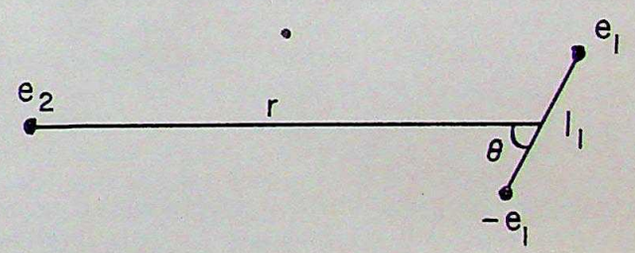

Figure 1. Ion-dipole interaction.

Many neutral molecules are dipoles. In the homogeneous field of an ion, such dipoles will be oriented in such a way that an attractive force results. Perfect orientation is counteracted by thermal motion, so that the attractive force varies with the degree of alignment. If the dipole (Fig. 1) is represented as consisting of two charges of magnitude $\pm e_1$ separated by a distance l, relatively small compared to the distance r from the ion of charge e_2, the force is

$$f = -(2e_1 e_2 l \cos \theta_1)/r^3$$

where θ_1 is the angle between the direction of the dipole and the ion-dipole axis. The dependence on r in this case is the inverse third power, and thus ion-dipole forces fall off more rapidly with distance than ion-ion forces. An important example of ion-dipole forces is the solvation of ions by polar molecules if no specific solvato complexes are formed.

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Next, there must also be attractive forces between pairs of dipoles. The field of one dipole tends to orient the direction of another, again subject to counteracting thermal motion. If one dipole consists of two charges $\pm e_1$ separated by a distance l_1, the other of charges $\pm e_2$ separated by l_2, and the two dipoles are at a distance r (large compared to l_1 and l_2) and form angles θ_1 and θ_2 with the line joining them, (Fig. 2), the attractive force is

$$f = \frac{3e_1e_2l_1l_2}{r^4}\,[2\cos\theta_1\cos\theta_2 + \sin\theta_1\sin\theta_2]$$

These forces are inversely proportional to the fourth power of r, and so fall off more rapidly with increasing r than those discussed previously; they are the pre-

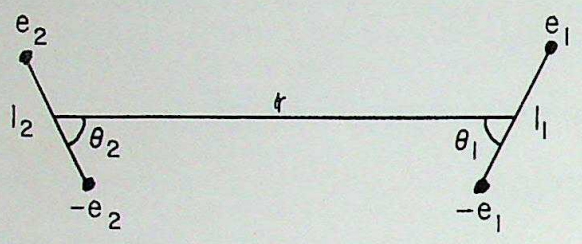

Figure 2. Dipole-dipole interaction.

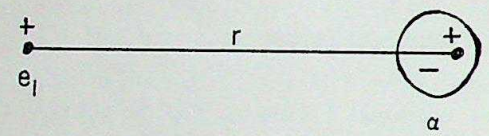

Figure 3. Ion-induced dipole interaction.

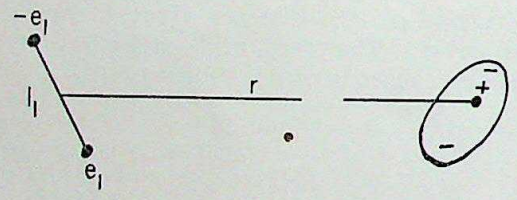

Figure 4. Dipole-induced dipole interaction.

dominant forces responsible for intermolecular attraction, and hence for condensation to liquid and for freezing of polar substances, such as chloroform.

With the exception of forces involving quadrupoles and higher poles, the forces listed are the only ones conceivable for particles made up from a *rigid* distribution of charges. Atoms and molecules, however, are not rigid. The motions of positive nuclei and negative electrons are separate and distinct, and application of an electric field to an atom or non-polar molecule will induce a dipole moment. Thus an ion induces a dipole in any near atom or molecule, and since electronic motion is very rapid compared to atomic motion, the dipole is always in the direction of the line joining the atom or molecule, and always so oriented that the net force is attractive (Fig. 3). The magnitude of this force is

$$f = -2\alpha e_1^2/r^5$$

where α is the polarizability of the atom or molecule, e_1 the charge of the ion, and r their separation. The dependence on r is of the inverse fifth power. These ion-induced dipole forces are weaker than ion-dipole forces, but are important in the solvation of ions by non-polar molecules.

Just as the electrical field of an ion is capable of inducing a dipole in a non-polar molecule, the field of a permanent dipole has a similar effect. Again, the orientation of the induced dipole is such that it points toward the permanent dipole, (Fig. 4), and leads to an attractive force, which is given by

$$f = -\frac{3\alpha e_1^2 l_1^2}{r^7}\,(3\cos^2\theta_1 + 1)$$

where the permanent dipole consists of charge $\pm e_1$ separated by a distance l_1 and inclined at an angle θ_1 to the line joining it to the atom or molecule of polarizability α at a distance r.

Since the electrons in atoms or molecules are in a constant motion the angular distribution of which is random, any atom or molecule has associated with it a dipole of constantly changing magnitude and direction. Maybe the easiest way of visualizing such a dipole is by considering the motion of one electron in the field of a singly charged nucleus, i.e., the hydrogen atom. It is immediately apparent that at any one moment this pair of particles represents a dipole moment—provided we make the classical assumption that at a given moment the electron may be localized at a particular point. Visualization of a momentary dipole for a many-electron atom is less straightforward; but there is no reason that, momentarily, the electrons should be symmetrically distributed about the nucleus—although in the time average they are—and hence atoms represent momentary dipoles. The same is true of molecules.

These changing dipoles of neighboring molecules are randomly oriented, and thus lead to no net force. But the existence of these *temporary* dipoles leads to the induction of added induced dipoles in neighboring molecules, and these always give an attractive force. These forces are the van der Waals or London dispersion forces, and as such are responsible, among other things, for the condensation of nonpolar substances, e.g., rare gases and methane to liquids and solids.

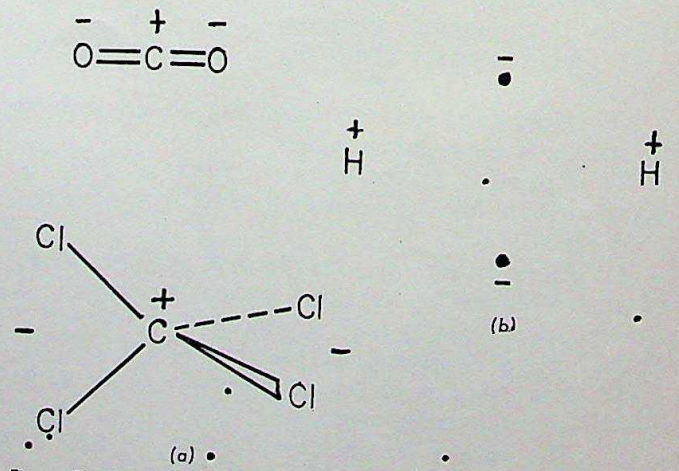

Figure 5. Quadrupoles.

In addition to the various forces listed, it must be realized that all molecules represent quadrupoles (and higher electric poles); two kinds of quadrupoles which are of different orders of magnitude should be distinguished. If bonds in a molecule are polar and

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the lack of dipole moment in the molecule, from the molecular symmetry (CCl_4, CO_2), rather large quadrupole moments can be expected (Fig. 5a). In molecules without polar bonds (e.g., homonuclear diatomic molecules), however, the high concentration of electrons in the bond leads to a quadrupole moment of smaller magnitude (Fig. 5b). The Coulombic forces between quadrupoles on the one hand, and ions, dipoles, and quadrupoles on the other can readily be calculated. Their magnitude, however, is generally so small that they make little or no contribution.

Finally, it must be pointed out that the equations given above break down when the separation of charges becomes of the same order of magnitude as the separation of particles. These equations give, however, an excellent qualitative picture of the forces involved and may well be used for calculations of orders of magnitude.

We have thus accounted for the forces involved in four items of our original listing: the ionic forces of an ionic crystal, the van der Waals and London forces of the molecular crystal, the cohesive forces of liquids, and the forces leading to solvation of ions and molecules. The interactions leading to molecule formation and to the formation of extended lattices are covalent bonding forces, and the metallic crystal may be envisaged in terms of the same covalent bonding forces, or by other quantum mechanical models, all of which will be discussed in the next section.

Covalent Bonds

Aside from this array of direct electrostatic interactions between ions, dipoles, induced dipoles, and higher poles, we must consider covalent or electron bond forces. Even though these forces are often specifically distinguished from electrostatic forces, we will show that they also are of electrostatic origin. However, their understanding requires the methods of quantum mechanics.

Quantum mechanics can be considered as based on the Schrödinger equation

$$H\Psi = W\Psi$$

as a fundamental postulate, which cannot be proved *a priori*, but which is justified *a posteriori* by comparison of the results derived with experiments. In this equation H is the *Hamiltonian operator;* Ψ, a function of all the space and spin coordinates of all particles under consideration, and of time, is called a *wave function*, or *eigenfunction;* and W is a differential operator involving time. For most molecular problems it is practical to remove from Ψ a factor containing the time dependence, in which case W simply becomes the total energy of the system. Without going into detail, we must take a closer look at the Hamiltonian operator H. It consists of two parts: the first of these involves the partial differentiation of Ψ with respect to space coordinates, and represents the *kinetic energy* of the particles.

The second part of the Hamiltonian operator represents *potential energy* of the particles. When written down completely, it is an infinite series, involving interaction terms for charges, dipoles, multipoles, both of electrostatic and magnetic nature. It is, however, a common experience of people working in quantum mechanics that, for calculation of energy quantities, including the binding energy of molecules, only the terms involving attraction and repulsion of charged particles are of importance. Hence a single term e_ie_j/r^2, representing the mutual electrostatic interaction of the particles i and j, is needed for each pair of particles. Additional terms, of course, must be included for any externally applied forces, but such forces are rarely of concern in discussions of bond energies.

In the treatment of molecules, the particles which are considered are the individual electrons (particularly valence electrons) and the nuclei (or kernels, i.e., nuclei including inner shells of electrons). In this case, the second part of the Hamiltonian represents the electrostatic attraction between electrons and nuclei (or kernels), and the electrostatic repulsions between pairs of electrons and between pairs of nuclei (or kernels).

Unfortunately it is impossible to solve the Schrödinger equation rigorously, for more than two particles, and consequently approximation methods must be used. Two main methods are available, and if carried to completion, give identical results. Usually however, it is impractical to carry either method to completion, and very approximate results are generally accepted. The two methods are the valence bond (VB) method (resonance method) due largely to Heitler, London, Slater, and Pauling, and the molecular orbital (MO) method, developed mostly by Hund, Mulliken, and Hückel.

Both methods are, in principle, capable of explaining the existence of molecules and chemical bonds. In practice, the calculations are so cumbersome that few treatments even approaching completeness have been reported save for some of the simplest molecules—mostly diatomic ones, linear triatomic ones, and hydrides. However, these calculations indicate that the existence of molecules, and of chemical bonds such as are responsible for extended lattices, are tractable by arguments—although quatum mechanical ones—based only on the electrostatic interactions of nuclei and electrons.

The same types of calculations can be applied to metallic crystals, although they become extremely cumbersome, involving, for example, the resonance of a single covalent bond between large numbers of nearest neighbors. A more effective argument is the treatment of the metal as a network of positive nuclei (or kernels) imbedded in a sea of electrons. This model can also be treated rather successfully quantum mechanically if only the electrostatic terms are included in the potential energy portion of the Hamiltonian operator.

Bibliography

Rice, O. K., "Electronic Structure and Chemical Binding," McGraw-Hill Book Co., New York, 1940.

Pauling, L., "Nature of the Chemical Bond," McGraw-Hill Book Co., New York, 1935.

Pitzer, K. S., "Quantum Chemistry," Prentice-Hall, Inc., New York, 1953.

Slater, J. C., "Quantum Theory of Matter," McGraw-Hill Book Co., New York, 1951.

Streitweiser, A., "Molecular Orbital Theory for Organic Chemists," John Wiley and Sons, New York, 1961.

Kauzman, W., "Quantum Chemistry," Academic Press Inc., New York, 1957.

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Prout's Chemical Bridgewater Treatise

The argument for the existence of God from the "wonder of His works," forms the province of natural theology. This was a subject of great popularity during the eighteenth and early nineteenth centuries (*1*), and one which seemed quite valid until Darwin's theory of evolution demolished it in its original form. Until then, no clergyman felt himself fully equipped unless he had a fair knowledge of natural history or natural science. In the seventeenth century, both Boyle and Newton had stressed that religion and science were not in conflict, and that the "Mechanical World Picture," far from leading to atheism, actually supported the existence of a Designer. "And thus much concerning God, to discourse of whom from the appearances of things, does certainly belong to Natural Philosophy," Newton had written (*2*). When Boyle left a sum of £50 at his death for the delivery of eight annual sermons—the Boyle Lectures—for the refutation of "notorious infidels," Richard Bentley, the first lecturer, drew examples from Newton's mechanics to prove the existence of a Deity.

The number of books written on natural theology is enormous, but they are all well epitomized by the most famous treatise on the subject, William Paley's immensely successful "Natural Theology" of 1803. It has been said of Paley's arguments that

> . . . he paid far too much attention to finding examples of apparent design in Nature, and not enough to the analogical inference that design in Nature (necessarily) implies the existence of a designer (*3*).

Bridgewater Treatises

This criticism also applies to the Bridgewater Treatises, "that strange and deadly series (*4*)" which appeared during the third decade of the last century. These eight treatises were sponsored by the will, dated 1825, of the eighth and final Earl of Bridgewater, Francis Henry Egerton, who died in 1829. Son of a bishop, Egerton was a clergyman who "assiduously neglected his parish (*4*)" for literary and historical scholarship. Now a scientist, he was nevertheless made a Fellow of the Royal Society in the days when the Royal Society was largely a gentlemen's dining club rather than a scientific institution. The Earl was an extremely rich man, for besides his legacy to the Royal Society, he also left £12,000 to the British Museum for the provision of his Egerton manuscripts. He was also one of England's great eccentrics.

The terms of the will must have provided a problem to the Royal Society's president, Davies Gilbert, who himself did not live to see the publication of the treatises. Eight thousand pounds had been invested in Bank Annuities stock and held at the disposal of Gilbert to be paid to the person or persons nominated by him. The person or persons appointed, were required to

> . . . write, print and publish, 1000 copies of a work on the Power, Wisdom and Goodness of God, as manifested in the Creation; illustrating such work by all reasonable arguments, as for instance the variety and formation of God's creatures in the animal, vegetable and mineral kingdoms; the effect of digestion, and thereby of conversion; the construction of the hand of man, and an infinite variety of other arguments (*5*).

Gilbert thought the task was too much for one man, and perhaps that £8000 was too great a windfall; hence, alone, or by consultation, he decided that the legacy should be broken down into eight lots of £1000—a decision that was harshly criticized by the "Edinburgh Review" and "Athenaeum." At this stage, Gilbert allocated the task of choosing the eight authors to the Royal Society Secretary, Peter Roget. Roget, who is widely known as the author of "Roget's Thesaurus," with the aid of the Archbishop of Canterbury and the Bishop of London, had by July, 1830 obtained the agreement of eight authors. Through 1833–6 the treatises appeared, and went through further editions well into Victoria's reign.

William Prout, Physician and Chemist

The eighth Bridgewater Treatise was "Chemistry, Meteorology and the Function of Digestion (*5*)" by the chemist and physician, William Prout, who is best known as the foremost nineteenth century exponent of the speculation that all the chemical elements possess atomic weights that are integral multiples of the atomic weight of hydrogen (*6*). Prout was born in 1785 at Horton in Gloucestershire. A country lad, he received a negligible education until, at the age of 17, he suddenly became aware of his own ignorance. Ambitiously, he inserted an advertisement in a local paper asking advice on his prospects for further education! A reply came from the Rev. Thomas Jones who ran a classical seminary near Bristol. Prout, who was later to name his youngest son Thomas Jones Prout, spent two happy years with Jones who interested Prout in the chemistry of Lavoisier and Davy and urged him to become a doctor. Prout entered Edinburgh University in 1808, and was graduated as an MD in 1811 with an uninspired dissertation on fevers. During his medical course he boarded with Alexander Adam, the Rector of Edinburgh High School, whose daughter, Agnes, he married in 1814. There were six children and the boys reflected Prout's new social status by becoming respectively soldier, lawyer, surgeon, and Oxford don.

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After receiving the best medical education possible to obtain in Britain, Prout came to London, where he set up a medical practice and soon established a reputation for work on what was then termed "Animal Chemistry"—in fact biochemistry. Over the years, with improved apparatus and techniques for organic analysis, he analyzed a tremendous variety of substances, prepared pure urea, and wrote a useful textbook of urine pathology which established him as a specialist on urinary and digestive disorders (*7*). In 1823, he analyzed the gastric juice and solved the old problem as to the nature of its vital ingredient, hydrochloric acid. From there he went on to consider the biochemistry of digestion and assimilation, in which his views foreshadowed those of Liebig.

Nevertheless, despite a list of impressive achievements, we find that, apart from *the* hypothesis, neglect of Prout's chemical and pathological work had already set in long before his death in 1850. There are two reasons for this. First, his active scientific career was essentially finished by 1834. Thereafter he devoted himself entirely to his medical practice and the revision of his books, while severe deafness prompted him to avoid scientific company. Second, in direct consequence, Prout was unable to keep abreast with the rapid scientific developments in chemistry and physiology, so that although much of his early research precursed that of Liebig and his school, in the main, Prout found himself overshadowed by the great achievements of the 1830's and 1840's. One aspect of this was his refusal to use chemical formulas and equations. The Royal Society, of which he was a Copley medallist, ignored his death, as did the infant Chemical Society; only the physicians remembered him and paid him handsome tribute in their chief medical journals. For the general public he was just an author of a Bridgewater Treatise.

There were three editions of Prout's treatise during his lifetime, and a posthumous fourth edition which appeared in 1855. John Tyndall, the agnostic physicist was asked to edit this final edition. His reaction was as might have been expected (*8*).

> . . . I should have thought more highly of Dr. Prout had I not read his book. Certainly if no better Deity than this can be purchased for the £8000 of the Earl of Bridgewater, it is a dear bargain. It is very evident that Dr. Prout would never have written such a book through the spontaneous promptings of his own spirit; it was written for money, and lacks even common scientific depth, not to speak of religious inspiration.

Tyndall had read his Paley in 1849, but not from any religious motive! He is quite wrong to say that the book lacked scientific depth; but as for the financial sneer (a common criticism that all the Bridgewater authors faced), although it would be rash to doubt Prout's sincerity, it might be pointed out that he had a large family, with children at public school, and later Oxford. We also know that he never spared any expense over apparatus. For instance, his barometer, which he designed himself, cost "an incredible sum of money." Indeed, the Royal Society, whose own standard barometer was modeled on that of Prout's and built under his supervision, haggled over the bill when it came to be paid.

The theological argument of the "Chemistry, Meteorology and the Function of Digestion" followed the pattern of finding examples of utility and design in both the inorganic and organic kingdoms, and by cumulative effort, argued that there is a unity of design and purpose which must spring from a beneficent and superior Being.

Divided into three books, Prout was equipped to discuss all three subjects, although in fact, the "Meteorology" is pedestrian and derivative. The third book on the biochemistry of digestion, was much in advance of contemporary knowledge, and it still reads well today, despite its vitalism and ignorance of pepsin and glycogen. It was in this section that Prout repeated his classification of foodstuffs into the three categories of saccharinous (carbohydrates), oleaginous (fats), and albuminous (proteins) (*9*), and suggested chemical mechanisms whereby these foodstuffs were ultimately converted into blood. A pioneer nutritionist, he always stressed the importance of a balanced diet, of which milk was "the great alimentary prototype." To copy this prototype was the whole art of good cookery.

Prout's Chemistry

The "Chemistry" is of considerable interest. Apart from a few historians of science, who know today that the word *convection* was first coined by Prout in this book, or that Prout clearly stated and accepted long before the majority of chemists what we today recognize as Avogadro's law (*10*)? His attitude toward the atomic theory of Dalton is best summarized in a letter he wrote to his friend Charles Daubeny in 1831.

> . . . There is no one can have a greater respect for Mr. Dalton, and all that he has done, than myself, and I am a firm believer in his principles *as far as they go*, because I believe them to be founded in truth (*11*).

However, Prout did not believe they contained "*all* the truth, and that consequently in *their present state* they are inadequate to explain the operations of nature." What were these inadequacies?

Dalton's classical atomic theory had assumed (*12*) that matter was composed of atoms that were qualitatively and quantitatively identical for the same element, or different for unlike elements. Since he had no chemical means for determining the molecular formulas of compounds, he simply assumed that compounds were binary, unless there were reasons to suppose otherwise. Thus, using Berzelian nomenclature, of the possible formulas of water, HO, H_2O, HO_2, H_3O, etc., Dalton chose the simplest, HO. He had then shown how this assumption could be fruitfully used to assign an atomic weight to every element, if the results of quantitative analysis were known. Thus, if water was HO, then the atomic weight of oxygen was 8 (H = 1). Dalton's *atomic* weights are of course *equivalent* weights.

The rule of simplicity was quite unsatisfactory, and the history of nineteenth century atomism may be read as a long search for reliable molecular formulas. This search was only completed by Cannizzaro in 1858, yet some minds, including that of Prout's, had seen the answer to the difficulty very much earlier, although their suggestions went by unnoticed or unapproved.

In the Bridgewater Treatise, Prout discussed Gay Lussac's law of combining volumes of gases, and Gay Lussac's and Dalton's law of gaseous expansion. He

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went on to remark that these were "very striking facts which apparently lead to the additional conclusion that —all perfectly gaseous bodies under the same pressure and temperature contain the same number of self-repulsive molecules." His argument was:

> ... If different gaseous bodies contained unequal numbers of self-repulsive molecules, the molecules of those gases which contain the least number, must exert the greatest self-repulsive power; in other words, the expansive energies of the molecules of a gas must increase as their number diminishes; and not only so, but the expansive energy must increase, neither more nor less, but exactly as the number of molecules diminishes. Such a conclusion would be obviously false; for if we imagine an extreme case, and suppose the number of self-repulsive molecules in a given volume of gas to be reduced to a few, or to one for instance, this single molecule must be supposed to exert a self-repulsive power, equal to the self-repulsive power exerted by myriads of molecules under ordinary circumstances.

It is not known when Prout arrived at Avogadro's law, but it must have been prior to 1815. We have his word that he arrived at the law independently of Avogadro, or the versions of Ampere and Dumas.

Dalton himself had thought of the hypothesis of equal volumes, but only to immediately reject it, since he identified what Prout was to call the *molecule* with the *atom*. To accept it was to destroy his axiom concerning the indestructibility of the atom. Thus,

1 vol. H (n atoms per vol.) + 1 vol. Cl (n atoms per vol.) → 2 vols. HCl ($n/2$ atoms per vol.)

In order to save the hypothesis, the atoms of the reactants would have to be "split" into two parts—a step Dalton was not prepared to make, so he abandoned the hypothesis. The alternative was to say that the "Dalton atom" was not *the* atom, but a particle, or molecule, or physical atom, composed from *at least* two indivisible chemical atoms.

However, Dalton and the majority of chemists refused to take this step, and it was left to Avogadro, Ampere, Prout, and later Dumas and Gaudin to point out the way for a more reliable set of criteria for the establishment of atomic weights.

Prout argued that the production of water proceeded according to, at least,

$$2H_2 + O_2 \rightarrow 2H_2O$$

and consequently the atomic weight of oxygen was 16 and not 8, or a volume of oxygen weighed 16 times an equal volume of hydrogen. He concluded,

> ... the weights of the self-repulsive molecules of all bodies are as the specific gravities (i.e., relative densities) of these bodies in the gaseous state; or bear certain simple ratios to these specific gravities.

Thus,

$$\text{Relative density of gas } x \text{ (H = 1)} = \frac{\text{Mol. wt. of } x}{\text{Mol. wt. of H}}$$

whence we derive the familiar equation, "molecular weight is twice relative density." Prout had stated this equation in the form,

$$\underset{(\text{air} = 1)}{\text{specific gravity of gas } x} = \left(\frac{\text{sp gr of oxygen}}{2}\right) \times \underset{(0 = 10)}{\text{at. wt. of } x}$$

in his famous anonymous paper of 1815, "On the Relation of the Specific Gravities of Bodies in their Gaseous State and the Weights of their Atoms (*13*)."

In this paper he incidentally noticed that the calculated relative densities were integral numbers. This led him to speculate that all the elements were condensed from hydrogen, or something simpler than hydrogen; and the abandonment of another Daltonian axiom—that there were as many atomic species as chemical elements. It has often been noticed that Prout's hypothesis was an explicit statement of hints and speculations dropped by Thomson and Davy, and that he was directly influenced by these chemists (*14*). However, we can go further and now suggest that the Bridgewater Treatise shows that Prout's acceptance of the "Avogadro law" prepared his mind to *split* the Daltonian atom whenever necessary. Hence, he found no difficulty in moving to the position where *all the elements* were polymers of the hydrogen atom or some simpler species.

In fact, having derived the law of Avogadro and having perceived its entailments, Prout saw no good reason not to permit the existence of molecular aggregates like (H_2O), $(H_2O)_3$, $(H_2O)_6$, etc., and series of combining weights, 3, 6, 9, 12, etc. Unlike Dalton and Avogadro, Prout never thought it necessary to build a simplicity rule into his atomic theory. Of the possible molecular equations satisfying Gay Lussac's and Avogadro's law,

$$2H_2 + O_2 \rightarrow 2H_2O$$
$$2H_3 + O_2 \rightarrow 2H_3O$$
$$2H_4 + O_4 \rightarrow 2H_4O_2$$
$$\text{etc.}$$

Avogadro had chosen the simplest consistent one. Indeed it was a source of criticism leveled against Avogadro: Why should molecules cease building at O_2, H_2, etc.? Why not H_3, H_4, O_4, etc.? Prout thought it likely that such molecules did exist.

> ... The molecule of water, on entering into combination, is often found to be divided into two, or three (perhaps more) parts. Now as we cannot admit the division of the ultimate molecule, or atom; we must of course conclude, that the molecules of oxygen and of hydrogen, are much more compounded ... and must each of them contain at least, three components, or submolecules. Hence the molecule of water will consist of at least nine component submolecules (viz. three of oxygen, and six of hydrogen) which we may suppose to be associated, in the first place, the hydrogen with the oxygen chemically; and afterwards the three submolecules of water with one another cohesively, so as to constitute one spherical molecule.

As a book of apologetics, probably Prout's Bridgewater Treatise had little scientific influence. His unitary hypothesis was already widely known, and in any case it was not figured prominently in the treatise. His views on atoms and molecules, which roughly coincided with the more publicized suggestions of Dumas in France, were discussed favorably by Daubeny in the second edition of his "Introduction to the Atomic Theory (*11*)." However, this did not appear until 1850, by which time Avogadro's law had already received its reappraisal from Dumas's pupils Laurent and Gerhardt, and was to be supported by Williamson after his return from France in the same year.

If we can find no use made of Prout's ideas, this need not in any way diminish the interest of his chemical Bridgewater Treatise to us, for it enables us to determine the attitude of a chemist who was prepared to think out, and when necessary reject, the basic assumptions of Dalton's atomic theory, rather than

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follow the majority of chemists who tended to take a phenomenalist or nonrealist attitude toward the atom. As Daubeny wrote: Prout showed

> . . . a thorough mastery of the details of his subject, but also much ingenuity in unraveling the mysteries which beset us when we attempt to speculate on the intimate constitution of matter.

Literature Cited

(1) Eiseley, L., "Darwin's Century," Gollancz, London, 1959, pp. 175-6. Gillespie, C., "Genesis and Geology," Harvard U.P., Cambridge, Mass., 1951.

(2) Newton, I., "Mathematical Principles of Natural Philosophy," Vol. 2, F. Cajori, editor, Univ. California, Berkeley and Los Angeles, 1962, p. 546.

(3) Gundry, D. W., "The Bridgewater Treatises and their Authors," *History*, 31, 143 (1946).

(4) Gillespie, C., *op. cit.*, p. 209.

(5) Prout, W., "Chemistry, Meteorology and the Function of Digestion," W. Pickering, London, 2 eds. 1834, 3rd ed. 1845, 4th ed. posth. 1855. See terms of will at front of all editions. All quotations are from the first, or third editions, copies of which are to be found in the Edgar Fahs Smith Memorial Collection, University of Pennsylvania.

(6) "Prout's Hypothesis," Alembic Club Reprints No. 20, Oliver & Boyd, Edinburgh, 1932.

(7) Partington, J. R., "A History of Chemistry," Macmillan London, Vol. 3, 1962, pp. 713-4.

(8) Tyndall's unpublished private journal, Nov. 19, 1854, in library of Royal Institution, London.

(9) Prout, W., *Phil. Trans.*, pp. 385-88, 1827. Prout received the Copley medal for this paper.

(10) First noted by Meldrum, A. N., "Avogadro and Dalton," Aberdeen, 1904, p. 40.

(11) Daubeny, C., "Introduction to Atomic Theory," Oxford, 1831, p. 131; 2nd ed. 1850, p. 471. The stresses are Prout's own.

(12) Conant, J. B., and Nash, L., "Harvard Case Histories in Experimental Science," Vol. 1, Harvard U.P., Cambridge, Mass., 1957, p. 228.

(13) Prout, *loc. cit.* (6), p. 29; Glasstone, S., J. Chem. Educ., 24, 478 (1947).

(14) Gregory, J. C., "A Short History of Atomism," London, 1931, p. 193; Benfey, O. T., J. Chem. Educ., 29, 78 (1952); Siegfried, R., J. Chem. Educ. 33, 263 (1956).

Who Discovered Galvanism?

Luigi Galvani, after whom galvanism is named, was an Italian biologist who was studying the effect of an electric current on the nerves of skinned frog legs. The electricity caused the muscles to undergo convulsions and the leg to twitch. According to encyclopedias, legend has it that Galvani's wife, nee Lucia Galeazzi, daughter of a teacher of anatomy under whom Galvani studied, was a woman of superior intelligence. One day as she was preparing frog legs for her husband's experiments she noticed that when her scalpel touched the metal of the machine on the table and was simultaneously in contact with the nerve of the frog leg, the leg twitched just as when an electric current was imposed. Galvani, in his writings, states that one of his assistants made this observation; and most encyclopedias seem to assume that Galvani's wife was that assistant.

Over the years as I encountered many interesting aspects of galvanism relating to the corrosion inside food cans, I developed a real admiration for Galvani's wife as a result of her observation, and felt that she should be given credit for the discovery of galvanism rather than her husband. But this admiration received a severe shock from a lecture entitled "The Guide of Life" by C. J. Ducasse, professor of philosophy at Brown University, as published in the January 1958 issue of Phi Beta Kappa's *Key Reporter*. According to Ducasse's version, Galvani's wife was a consumptive, and her physician prescribed broth from frog legs to strengthen her. One day as Galvani stood on his balcony which had an iron railing to prepare frog legs for his wife's broth, he hung the prepared legs on the railing with copper hooks. He observed the same muscular contraction and twitching that an electric current caused. This version of the discovery, I find, has received ridicule in the literature as being an old wives' tale: If Galvani were cooking for his wife, he would more likely be doing it in the kitchen rather than in his laboratory or on his balcony. Moreover, why should he use copper hooks to hang the legs? To me, it seems strange that a physician, whom one would assume to be of a high order, would believe that the tremendous strength of frog legs would be an inherent property of the broth made from them. After all, Galvani was a biologist, and as such it is doubtful that he would harbor such a notion.

Neither Professor Ducasse nor I have been able to find conclusive evidence for the correctness of either of these stories. Recently I have checked through translations of Galvani's original publications dealing with this theme.

There is no doubt that Galvani studied the bimetallic effect on the nerves of many dead animals. He noted the effect of electricity produced by friction and electricity from a Leyden jar. He studied the effect of electricity from lightning at various distances and correlated this effect with the peals of thunder at great distances. Of most significance was his study of what has been termed a "marine torpedo," an electric animal, perhaps what we know as an electric eel. After finding that many sources of electricity applied to the nerves of dead animals caused muscular contraction, he found that the electricity from the marine torpedo had the same effect. As a biologist, he was not diverted from his contention that he was observing animal electricity, "De Viribus Electricitatis." When there was no lightning and he hung frog legs with copper hooks on his iron railings, he felt that he had discovered atmospheric electricity.

Probably his greatest achievement, as far as galvanism is concerned, was the arousal of interest in Alessandro Volta. When Galvani's work first came to Volta's attention, the latter was inclined to accept Galvani's idea that the electricity involved was animal electricity. He interpreted it as an upset in the amount of electricity in the muscle and in the nerve; the two metals served to complete the circuit and restore the balance. But as Volta experimented himself, he soon changed his mind. He first observed that when he placed a piece of tinfoil on his tongue in contact with a silver coin, there developed what he called a sourness. When he made his eye a part of the circuit between two metals, it created a sensation of light just as a blow on the eye does. Volta was soon convinced that the two metals were responsible for the electricity.

Then began the heated argument that is said to have led to the discovery of useful electricity. But the controversy was not between Galvani and Volta as is usually stated. Rather it was between Volta and Galvani's nephew, Giovanni Aldini, professor of physics at Bologna University. Galvani is reported to have tried to answer Volta in only one publication. He seems never to have realized that the electricity involving two metals results from a change in one or both to produce electric energy. Galvani reported that an assistant first noted the bimetallic effect on frog legs, though there seems to be no record of the identity of the assistant. I am quite willing to assume that the assistant was his wife.

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Proceedings of the

California Associatisn of Chemistry Teachers

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Terpenes to Platinum: The Chemical Career of Lev Aleksandrovich Chugaev

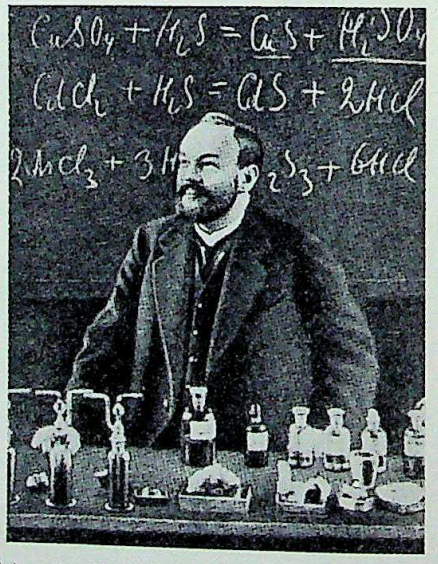
Virtually every college freshman who is exposed to a course in qualitative analysis is familiar with the scarlet precipitate formed by the reaction of nickel(II) ion with dimethylglyoxime, the first organic spot test reagent used to detect a metal ion. Yet, it is probable that only chemists concerned with coordination compounds are aware that this analytically important reaction (Chugaev's reaction) was but one of many discoveries made in varied fields of chemistry by Lev Aleksandrovich Chugaev.

Chugaev (1873–1922) was the foremost figure and undisputed leader of a group of Russian chemists who systematically explored the coordination compounds of platinum and its congeners. His versatility rivaled that of Mendeleev, his predecessor in the chair of inorganic chemistry at the University of St. Petersburg. His scientific contributions ranged through bacteriology, biochemistry, organic chemistry—especially that of the terpenes, optical rotatory dispersion, coordination compounds, and analytical chemistry. He was also founder and first director of Russia's world-famed Platinum Institute.

In view of the magnitude of Chugaev's contributions it is indeed astonishing that the only biographical data available in English is in a short 3-page obituary (*1*), which appeared shortly after his premature death at the age of 49. This prolific worker, for whom chemistry was paramount and for whom personal life was almost non-existent, produced more than a hundred articles during his short scientific career. The biographical data in the present paper are taken largely from a tribute presented by Chugaev's student and co-worker, the late V. V. Lebedinskiĭ, on November 13, 1944, in Moscow at the Third Conclave on the Chemistry of Complex Compounds (*2*).

Life

Lev Aleksandrovich Chugaev, the son of a physics teacher, was born on October 4, 1873, in Moscow and received his primary education in a military academy.[2] As a student in the Natural Sciences section of Moskovskiĭ Universitet (Moscow University), he studied inorganic chemistry under I. A. Kablukov and organic chemistry under N. D. Zelinskiĭ, with whom he published his first chemical paper in 1895. Following his graduation from the University in that year, he was appointed *Adiunkt* (assistant) in the Chemical Laboratory of the Bacteriological Institute. In 1903, he successfully defended his dissertation "Issledovanie v Oblasti Terpenov i Kamfary" (Research in the Area of Terpenes in Camphor) and was granted the degree *Magistr Khimii* (Master of Chemistry). From 1904 to 1908, he was Professor at the Moskovskoe Tekhnicheskoe Uchilishche (Moscow Technical High School).



Lev Aleksandrovich Chugaev lecturing on qualitative analysis.

Presented in part before the Division of the History of Chemistry at the 144th Meeting of the American Chemical Society, Los Angeles, California, April, 1963.

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[2] The author is indebted to Dr. Louis Schmerling, Universal Oil Products Company, for the information that Chugaev was a maternal half-brother of V. N. Ipatieff. For this, and other personal reminiscences about Chugaev, see "The Life of a Chemist: Memoirs of Vladimir N. Ipatieff," edited by X. J. Eudin, H. D. Fisher, and H. H. Fisher, Stanford University Press, 1946.

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In 1906, he was awarded the degree *Doktor Khimicheskikh Nauk* (Doctor of Chemical Sciences) for the successful defense of his dissertation "Issledovanie v Oblasti Kompleksnykh Soedinenii" (Research in the Area of Complex Compounds). In 1908, he was appointed Professor of Inorganic Chemistry at S. Peterburgskii Universitet (St. Petersburg University). He occupied this chair, which was formerly held by Mendeleev, Konovalev, and Walden, until his death in 1922. He simultaneously occupied the chair of organic chemistry at the Leningradskii Khimiko-Tekhnologicheskii Institut (Leningrad Chemico-Technological Institute).

Chugaev's death can be attributed directly to the deplorable conditions in post-revolutionary Russia. When life in Petrograd had become almost impossible, he moved his wife and two sons to Vologda, a city some hundred miles north of Moscow. During one of his visits to his family, he contracted typhus, to which he succumbed on September 26, 1922. His death was a serious loss for chemistry in general and a real disaster for Russian chemistry in particular. His older son, Aleksander L'vovich, had died in 1921 after finishing secondary school. The younger, Vladimir L'vovich, a chemical engineer, died in 1941. Chugaev's wife, Aleksandra Aleksandrovna, died in Leningrad in 1942.

Some idea of the esteem in which Chugaev was held by his colleagues may be gained from the fact that following his death one of his students, E. Kh. Fritsman (1879–1942), devoted himself for many years to the posthumous publication of Chugaev's accumulated research. Even today Chugaev's influence still continues in the works of his students, of whom I. I. Chernyaev and A. A. Grinberg are prime examples.

Lev Aleksandrovich Chugaev was one of those individuals who devote themselves exclusively to science to the almost complete rejection of their personal lives. His *modus operandi* has been described by Lebedinskii (*2*). Chugaev seldom went to entertainments and he rested only infrequently. On those days on which he was free of lecturing duties, he would occupy himself with experimental work from early morning until late at night with only short hurried "breaks" for meals. Several times each day he found time to visit his students and co-workers in the laboratory, to discuss their work with them, and to communicate to them some of his own contagious enthusiasm. His students emulated his behavior by sometimes working until the early hours of the morning. Chugaev's quarters at St. Petersburg University occupied the same building as the laboratories and often in the middle of the night Chugaev would appear in the laboratory in his night robe to question his students about their work. He was impatient with the inevitable frustrations of experimental work, and his compulsive nature drove him to complete each project at a breakneck pace. The light in Chugaev's study would invariably burn until 4 or 5 A.M. where, surrounded by books and journals, he would be intent on his current research.

Chugaev's Work

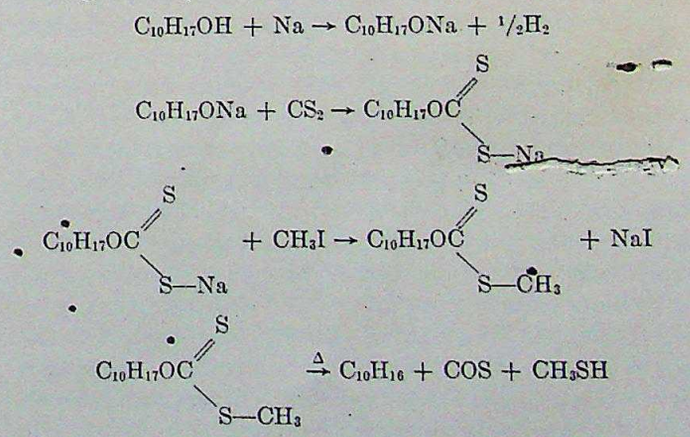
Chugaev's earliest works were primarily biochemical and bacteriological. In studying the action of poisons on microorganisms, Chugaev sought a relationship between structure and toxicity. He linked toxicity with the presence of an aldehyde group and showed that a decrease in toxicity accompanies an increase in molecular weight and an even greater decrease occurs when the aldehyde is transformed into the corresponding ketone or acetal or when hydroxyl groups are introduced into the aldehyde molecule. On the other hand, introduction of a phenyl group or a halogen atom into the aldehyde or ketone molecule considerably increases its toxic properties.

In his study of phosphorescent bacteria, Chugaev attempted to relate the sugar concentration in the culture medium to the intensity of bacterial glow. He demonstrated that only very small concentrations (0.1%) of carbohydrates exert a favorable influence on the growth and glow of bacteria. Continuing this research further, Chugaev in 1898 proposed a new theory for the disinfecting action of the enzyme oxidase.

An interesting phenomenon early investigated by Chugaev was triboluminescence, the property possessed by some crystalline substances of becoming luminous when crushed, rubbed, or mechanically pressed together. Careful investigation of some 500 organic and inorganic substances showed about one fourth (chiefly organic) to be triboluminescent. The property appeared to be associated particularly with ring compounds. Certain groups such as hydroxyl, carbonyl, and secondary or tertiary amino especially favored triboluminescence; among many asymmetric compounds, the optically active antipodes were found to exhibit triboluminescence, whereas the racemic mixtures did not (*3*). Substitution of triboluminescent substances for zinc sulfide in the spinthariscope led to a paper on the theory of this instrument (*4*).

Terpenes

Chugaev's most outstanding contribution to terpene chemistry is undoubtedly his xanthogen method, which makes possible the conversion of alcohols into their corresponding optically-pure unsaturated hydrocarbons uncontaminated by isomeric compounds (*5*). The alcohol is first converted to the sodium alcoholate, which is then reacted with carbon disulfide to form a xanthogenate. Reaction of the latter with methyl iodide produces a xanthogen ester, which on careful heating decomposes to form the terpene hydrocarbon.



The xanthogen method enabled Chugaev to obtain for the first time optically and structurally homogeneous menthenes, inactive pinene, and other hydrocar-

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bons, to separate isomeric alcohols obtained in synthesis or in natural products, and to discover a number of new hydrocarbons—α- and β-thujene (tanacetene), thujane (tanacetane) (*6*), bornylene (*7*), isolimonene, and α- and β-cholesterylenes (*8*). At the time of its discovery, Chugaev's reaction served to introduce a measure of clarity into an extremely complex area of organic chemistry; it is still widely used today in organic synthesis.

Chugaev's contributions to organic chemistry were not limited to investigations of terpenes but ranged over the entire field. For example, his first published chemical paper (1895), a study of dihydroxymethylglutaric acid (*9*), carried out jointly with Nikolaĭ D. Zelinskiĭ of Hell-Volhard-Zelinskiĭ fame, was followed by a test for hydroxyl groups by use of organic magnesium compounds (*10*), an attempt to synthesize haemopyrrole (*11*), a new synthesis of α-diketones by the action of Grignard reagents on vinylideneoxanilide (*12*), selenomercaptans and their derivatives (*13*), an anomaly in the molecular refraction in substituted glyoximes (*14*), and an investigation of dithiocamphocarboxylic acid (*15*).

Anomalous Rotatory Dispersion

With the pure, optically active compounds placed at his disposal by his xanthogen method, Chugaev turned to a study of the optical properties of organic compounds, an area in which he soon became a world authority. As early as 1898, he had begun a study of the relationship between optical rotation and constitution. He found that in a homologous series the rotation increases to an approximately constant value with increasing molecular weight (Chugaev's rule) (*16*). He also observed the moderating effect of substituent groups on optical rotation.

Beginning in 1909, Chugaev initiated an intensive study of anomalous rotatory dispersion which resulted in more than a dozen publications within five years (*17*) and culminated in an invited paper presented before the Faraday Society in London on March 27, 1914. In this paper (*18*), which he was unable to present in person, he clearly discussed the three distinct causes which might independently give rise to anomalous rotatory dispersion.

The majority of colorless, optically active compounds exhibit normal rotatory dispersion, in which a plot of specific rotation, $[\alpha]$, versus the wavelength of incident light, λ, is hyperbolic and $[\alpha]$ increases regularly with decreasing wavelength (*19*). Anomalous rotatory dispersion exists in those cases in which the $[\alpha]$ versus λ curve has a maximum and passes through zero or in which $[\alpha]$ decreases with decreasing λ. Biot, who first discovered this behavior, showed that two substances, each of which has a normal rotatory dispersion separately, can, upon mixing, give a mixture with an anomalous rotation as a result of superposition, provided that the rotations of the two components at the same wavelength differ in both absolute value and sign. Such anomalous rotatory dispersion, due to nonhomogeneity, is called the Biot type.

Chugaev discovered a new type of anomalous rotatory dispersion—intramolecular anomalous dispersion. He was able to prepare compounds containing two oppositely rotating carbon atoms in which the Biot type anomaly was realized within the same homogeneous molecule (e.g., *l*-menthyl *d*,β-camphorsulfonate) (*17b*). He extended his studies to colored compounds and investigated the parallelism between optical rotation and absorption spectra (*17g*). He also showed that the Cotton effect, i.e., the fact that the maximum in the rotatory dispersion curve lies in the vicinity of the absorption in the visible portion of the spectrum, could be extended to substances whose absorption bands lie in the ultraviolet region (*17c,d*). In addition, Chugaev and his co-workers showed that substances possessing normal rotational dispersions at one temperature or in one solvent may become anomalous at another temperature, or in another solvent (*17h,m, 18*). A posthumous paper dealt with anomalous rotatory dispersion of essential oils (*20*).

Chugaev's studies of optical activity were not only of theoretical interest, but some were of analytical significance. For example, in 1911 he showed how measurement of the rotatory dispersion coefficient

$$\sigma = \frac{[\alpha]_F}{[\alpha]_C}$$

(where $[\alpha]_F$ and $[\alpha]_C$ are the specific rotations for Fraunhofer wavelengths *F* (4861 Å) and *C* (6563 Å), respectively) could be used for the analysis of optically active mixtures, viz., *d*- and *l*-menthone (*17c*). The same method could be applied to chemical reactions. Thus Chugaev was able to follow the decomposition of *l*-bornylxanthogenic acid into borneol and carbon disulfide by plotting rotatory dispersion curves at frequent intervals and noting the disappearance of abnormal dispersion and the gradual change to the curve characteristic of borneol (*17e*).

Chugaev's studies of optical properties were not confined to organic substances. Together with Sokolov (*21*), he made the first observation of the stereospecificity of inorganic coordination compounds, an important phenomenon whose systematic study is a relatively recent innovation. An octahedral complex containing three molecules of an optically active bidentate ligand would be expected to exist in a large number of stereoisomeric forms. For example, if all of the predicted isomers and all the total and partial racemates of the tris(propylenediamine)cobalt(III) ion were found, the chemistry of such complexes would be complicated (*19b*). However, Chugaev and Sokolov found that coordination compounds containing optically active ligands exist in only certain preferred forms; i.e., all the combinations are not of equal stability. In this case, the only isomers which were isolated were D-[Co *d*-pn$_3$]Cl$_3$ and L-[Co *l*-pn$_3$]Cl$_3$ and the totally inactive racemic mixture of these two.

Coordination Chemistry

Chugaev early noted the similarity between organic compounds and inorganic complex compounds; and although he was trained as an organic chemist, it is in coordination chemistry, a field in which he continued to work from 1904 until his death, that his fame securely rests. In his own words,

> The properties and transformations of complex compounds show that these compounds exhibit an amazing analogy to carbon compounds, which are dealt with in organic chemistry.

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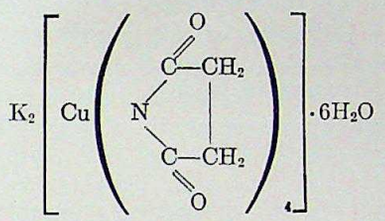
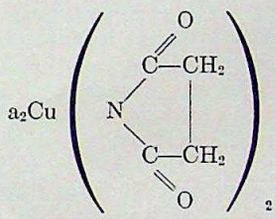
Here we have the same versatility of types, the same gradations in the degree of mobility of atoms, such as, for example, halide atoms in molecules, and the same phenomenon of isomerism, which are, as is known, extremely rare among inorganic compounds. From this viewpoint it appears extremely interesting and important to begin a systematic study of these compounds with those experimental and theoretical techniques which have already given us tremendous service in the area of organic chemistry (*2*).

The original objects of Chugaev's entry into this field were the compounds formed by Cu(II), Ni(II), and Ag(I) with organic imides, particularly succinimide (*22*). Chugaev demonstrated that a hydrogen atom of imides of carboxylic acids can be substituted by a metal ion to form abnormally colored salts, which in turn can form stable complexes with ammonia and aliphatic amines. Such compounds are related to the copper compounds obtained in the biuret reaction, a test for the presence of peptides, proteins, and amino acids which contain the —CONH— group. They differ only in their lesser stability toward water and in containing two molecules of succinimide corresponding to one of biuret. The red-violet potassium salt,



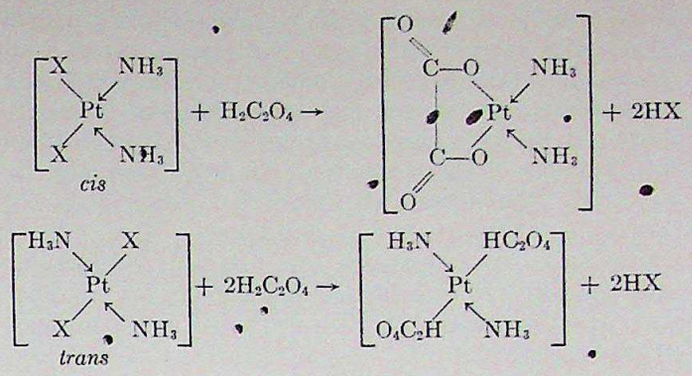
and the red compounds,



where a = an amine, are typical of this series. In order to ascertain how general were his observations of the behavior of amines toward copper succinimide, Chugaev extended his studies of reactivity to various amines and compounds of Cu(II), Ag(I), and Pt(II) and (IV) (*23*). He found that primary amines form complexes easily, secondary amines much less readily, and tertiary amines, except for pyridine, not at all.

Ring Stability

In order for a molecule with two potentially coordinating groups such as a diamine, $NH_2(CH_2)_nNH_2$, or an amino acid, $NH_2(CH_2)_nCOOH$, to function as a chelate group, it must be geometrically possible to form a ring of low strain. From organic chemistry, it is known that 5- and 6-membered rings are the most stable, whereas 4-membered rings are less stable and 3-membered rings are quite unstable (Baeyer's strain theory). That these relationships were completely applicable to complex compounds was shown by Chugaev as early as 1906 (Chugaev's rule of rings) (*24*). This rule served as a point of departure for stereochemical research not only by Chugaev but also by other workers. The widely used diagnostic method for determining the configuration of coordination compounds of Pt(II) by reaction with oxalic acid, which was subsequently developed by Chugaev's pupil A. A. Grinberg (*25*), provides an excellent example of the stability of a 5-membered ring:



Chugaev clearly showed the stability of pentatomic and hexatomic ring systems by comparing the ease of formation of complexes of Co(III), Ni(II), and Pt(II) with various diamines. Dimethylenediamine and trimethylenediamine readily formed complexes in contrast to higher polymethylenediamines. That 5-membered saturated ring systems are favored over 6-membered systems was shown by the lesser stability of trimethylenediamine compounds compared to the analogous propylenediamine compounds. Also, disulfides and diselenides, $R(S,Se)(CH_2)_n(S,Se)R'$, form complexes with Ni(II) and Cu(II) only when $n = 2$ (*26*). The tendency toward the formation of 5- and 6-membered rings and the greater stability of the former was further shown by Chugaev and Serbin's study of the formation of inner complexes of Cr(III) with various amino acids as a function of the separation of the carboxyl and amino groups (*27*). The α-acids formed inner complexes readily, whereas the β-acids did so with some difficulty; inner complexes could not be obtained at all with γ-, δ-, and ϵ-amino acids.

By assuming that ring compounds are more stable than open-chain compounds and that 5- and 6-membered rings are the most stable, Chugaev was able to explain the stabilities of numerous coordination compounds. Thus ammonia, monoamides, hydrazines, and γ-amino acids form relatively unstable compounds, whereas ethylenediamines and propylenediamines, amidines and amidoximes, 2,2′-bipyridines and phenanthrolines, α- and β-amino acids, nitrosoguanidines and aminoguanidines, and other compounds containing coordinating groups in the 1,2 or 1,3 positions form stable complexes. For the same reasons, compounds containing no nitrogen such as the salts of oxalic, α-oxy aliphatic, carbonic, and sulfuric acids are more stable than salts of open-chain monovalent acids.

Dioximines

Since Chugaev was trained as an organic chemist, it is not surprising that his first research on the metals of periodic group VIII (Fe, Co, Ni, Pd, and Pt) was a study of their reactions with organic reagents, viz., the α-dioximes (*28*). This resulted in his best known discovery, the reaction of Ni(II) with dimethylglyoxime, the first organic spot test reagent used to detect a metal ion. By use of this reagent one part of nickel may be detected in 2 million parts of water, even in the presence of large concentrations of cobalt. By use of a similar reaction, one part of iron may be detected in 165 million parts of water (*29*). The reaction was also applied to the separation and determination of pal-

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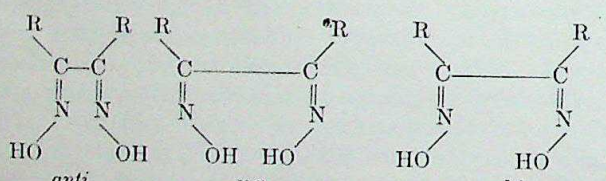
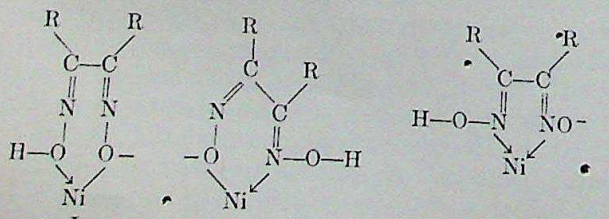
ladium by Wunder and Thüringer (*30*). The products formed by coordination of α-dioximes, which contain a labile hydrogen atom, with metallic ions and named dioximines by Chugaev are examples of inner complexes, i.e., nonelectrolytic compounds in which the coordinating groups through chelation satisfy simultaneously both the oxidation number and the coordination number of the metal ion. Because they may be extracted into organic solvents, such compounds are useful in effecting analytical separations. Their intense colors make them suitable for qualitative detections and quantitative colorimetric determinations of metal ions, and their insolubility forms the basis of a number of gravimetric methods. Along with Il'inskiĭ, who first employed α-nitroso-β-naphthol for the determination of cobalt in 1885 (*31*), Chugaev was a pioneer in the application of inner complexes to analytical chemistry.

Although the dioximines of cobalt, which were synthesized in great numbers by Chugaev (*32*), have no analytical significance, they were of great theoretical importance in the development of coordination chemistry. The Blomstrand-Jørgensen chain theory excluded the possibility of nonelectrolytic complexes, whereas the Werner coordination theory predicted the existence of such compounds (*33*). Since the number of such stable nonelectrolytic complexes was extremely small at the beginning of the twentieth century, the cobalt dioximines and the measurement of their conductances played a crucial role in the triumph of the coordination theory which Chugaev firmly supported.

The studies on dioximines were intimately connected with Chugaev's rule of rings, which runs through his research on complexes like a unifying thread. A single oxime group shows little tendency toward coordination, but when it can form part of a chelate ring, as in a dioxime, the nitrogen atom becomes a good electron pair donor. Symmetrical dioximes can exist in three isomeric forms:



Of the three isomers of dimethylglyoxime, Chugaev found that only the *anti* isomer forms the characteristic scarlet precipitate with Ni(*II*). He thus was able to use complex formation as a method for determining the isomeric configuration of α-dioximes. The scarlet precipitate was first believed by Chugaev to contain an improbable 7-membered ring (I), but this idea was later revised in favor of a 6-membered ring (II). Pfeiffer's (*34*) formulation of a 5-membered ring (III) has been supported by X-ray data (*35*) which showed the presence of multiple rings involving extremely strong hydrogen bonding (IV).



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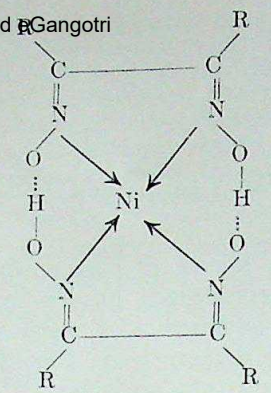

IV

Platinum Compounds

Chugaev did not limit himself to the study of the coordination compounds of Fe, Co, Ni, Cu, and other non-noble metals, but soon began a comprehensive and systematic investigation of the complexes of platinum and its congeners. In fact, to quote Gilchrist, "the character of practically the entire Russian output of researches on the chemistry of the platinum metals reflects the influence of Chugaev" (*36*). Since for many years Russian chemists have made more contributions to this field than those of any other nation, this is no mean achievement. Chugaev explained his interest in this area as follows:

> Each element of the platinum group represents, as it were, its own miniature organic chemistry, in which, as if in a mirror, are reflected the features of its chemical individuality. The combined totality of these organic chemistries, however, deviates from general similarities to the compounds of carbon so much that the classic structural theory of Kekulé-Butlerov proved inapplicable; a different, broader, and more flexible theory became necessary, the attempt at the discovery of which was made by the professor from Zürich, Alfred Werner (*2*).

Chugaev, like chemists before him and after him, realized that stereochemical studies could best be made with elements whose complexes were stable, i.e., with the platinum metals.

Chugaev's earliest and most extensive research in this field dealt with coordination compounds of organic sulfides and disulfides (*37*). A bibliography of such work has been compiled by E. Kh. Fritsman (*38*). Werner's coordination theory predicts only two stereoisomers (*cis* and *trans*) for compounds of type $[MA_2B_2]$ if the configuration is square planar. In an important study in this series (*39*), Chugaev showed by its reaction with tetrammineplatinum(II) chloride to give Magnus' green salt that the third (γ) isomer of $[Pt\{(CH_3)_2S\}_2Cl_2]$ was actually an electrolytic "polymerization" isomer, rather than a stereoisomer:

$$[Pt\{(CH_3)_2S\}_4][PtCl_4] + [Pt(NH_3)_4]Cl_2 \rightarrow [Pt(NH_3)_4][PtCl_4]\downarrow + [Pt\{(CH_3)_2S\}_4]Cl_2$$

In the same work, it was also shown that the same relationships hold for the more stable disulfide complexes. Thus the red form of empirical formula $[Pt\{C_2H_4(SEt)_2\}Cl_2]$ was shown to be $[Pt\{C_2H_4(SEt)_2\}_2][PtCl_4]$. Since this time, similar examples of "polymerization" isomerism have been reported (*40*). Under certain conditions, such as heating, the "polymerization" isomer may decompose to form the monomer (*39, 41, 42*). This phenomenon of "depolymerization" is not limited to Pt(II) complexes, but also

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occurs in the case of complexes containing both Pt(II) and (IV),

$$[Pt\{(CH_3)_2S\}_4][PtCl_6] \xrightarrow{\Delta} [Pt\{(CH_3)_2S\}_2Cl_2] + [Pt\{(CH_3)_2S\}_2Cl_4] \quad (43)$$

as well as complexes containing more than one metal,

$$[Ag(NH_3)]_2[PtCl_4] \xrightarrow{\Delta} [Pt(NH_3)_2Cl_2] + 2AgCl \quad (42)$$

In accordance with Chugaev's rule of rings, organic disulfides were found to form more stable complexes than do the monosulfides; of the compounds, $RS(CH_2)_nSR$, only compounds with $n = 2$ were found to form stable, well-characterized chelates (*26*, *39*, *41*, *44*, *45*). By conductance measurements (*44*), Chugaev was able to follow the course of reactions such as

$$[Pt\{RS(CH_2)_nSR\}Cl_2]^0 + RS(CH_2)_nSR \rightarrow [Pt\{RS(CH_2)_nSR\}_2]^{2+} + 2Cl^-$$

and thus determine the relative stabilities of different ring systems. Use of the same physicochemical method (*46*) to determine the extents of dissociation and reaction of the isomers of organic monosulfides such as $[Pt(Et_2S)_2Cl_2]$ (*47*), led Chugaev to conclusions which were later explained by his student Chernyaev in terms of the *trans* effect (*48*).

Another series of platinum complexes to which Chugaev devoted much time was the chloropentammines of tetravalent platinum. Every book dealing with coordination chemistry, whether introductory or advanced, includes almost without exception the familiar V-shaped plot of the molar conductances of the series of Pt(IV) ammines versus the number of chlorine atoms introduced into the coordination sphere. The popularity of this graph no doubt stems from the numerous principles it illustrates—the formation of a series of complexes due to stepwise displacement of a ligand by an anion entering the coordination sphere, the effect of such entry on the charge of the complex and on the number of ions present, the determination of the number of ions by conductance measurements, and the preservation of the coordination number during these changes. A graphical presentation usually omits the fact that the crucial second series in this group of Pt(IV) ammines, the chloropentammines which were predicted by Werner's theory, was missing until Chugaev was finally able to synthesize a compound by the action of ammonia on ammonium hexachloroplatinate(IV) (*49*):

$$(NH_4)_2[PtCl_6] + NH_3 \rightarrow [Pt(NH_3)_5Cl]Cl_3 + 2NH_4Cl$$

As predicted, Chugaev and Vladimirov found the conductance, Λ_{1024}, (404 ohm^{-1} cm^2, 4 ions) intermediate between that for $[Pt(NH_3)_6]Cl_4$ (523 ohm^{-1} cm^2, 5 ions) and $[Pt(NH_3)_4Cl_2]Cl_2$ (229 ohm^{-1} cm^2, 3 ions). They also established the charge on the cation in solution by measurement of the critical coagulation concentration (CCC), a technique based on the Schulze-Hardy rule which states that the CCC at which an electrolyte causes rapid coagulation of a colloidal system depends on the charge of the counter-ion (*50*). In view of its importance in the development of coordination chemistry, in 1925 $[Pt(NH_3)_5Cl]Cl_3$ was officially named "Chugaev's salt" by decree of the Fourth Mendeleev Congress.

The newly discovered Pt(IV) acidopentammines also enabled Chugaev to make a valuable contribution to acid-base theory. The classical studies in this area by Niels Bjerrum and J. N. Brønsted had shown that hydrates, especially those of highly charged metallic ions, are acidic since the coordinated water molecules can lose protons to form hydroxoaquo complexes:

$$[Al(H_2O)_6]^{3+} + OH^- \rightarrow [Al(H_2O)_5(OH)]^{2+} + H_2O$$

Chugaev showed that an analogous reaction takes place with ammines, but to a lesser extent than with hydrates, and he simultaneously discovered a new series of acidoamidotetrammines of Pt(IV) (*49a,b*, *51*):

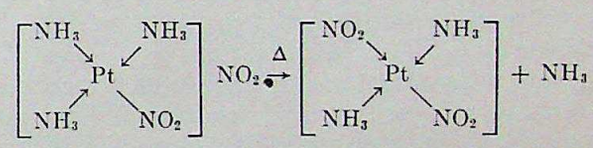
$$[Pt(NH_3)_5Cl]^{3+} + OH^- \rightarrow [Pt(NH_3)_4(NH_2)Cl]^{2+} + H_2O$$

The compounds of this new series are basic and readily react with acid to reform the original acidopentammines:

$$[Pt(NH_3)_4(NH_2)Cl]^{2+} + H^+ \rightarrow [Pt(NH_3)_5Cl]^{3+}$$

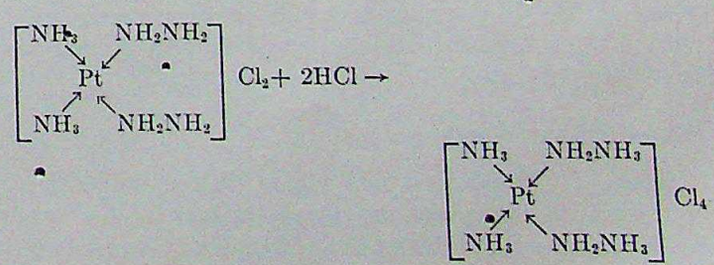
Chugaev also prepared a new series of Pt(IV) hydroxopentammines and showed that $[Pt(NH_3)_5OH]^{3+}$ is a much weaker base than the corresponding cobalt(III) complex, $[Co(NH_3)_5OH]^{2+}$, which has a smaller charge (*49a,b*, *51a,c*, *52*). The acidity of other coordinated molecules which contain protons has since been demonstrated by other workers, particularly Chugaev's student Grinberg.

Chugaev made a thorough study of the nitro complexes of divalent platinum and of the relationships between the reactions of the members of the series $[Pt(NH_3)_4](NO_2)_2$, $[Pt(NH_3)_3NO_2]NO_2$, *cis*- and *trans*-$[Pt(NH_3)_2(NO_2)_2]$, and $K_2[Pt(NO_2)_4]$ (*53*). On heating the second member of this series, Chugaev obtained the *trans* isomer of the third member:



This reaction, which shows that the molecule of ammonia *trans* to a highly electronegative NO_2 group is more easily replaced than are the two mutually *trans* ammonia molecules, was later explained by Chernyaev's *trans* effect (*48*).

Chugaev and co-workers first prepared and established the structures of coordination compounds of platinum containing ligands such as aminoacetal (*54*), nitriles (*55*), isonitriles (*56*), hydroxylamine (*52*, *57*), water (*58*), the sulfito group (*59*), and hydrazine (*60*). Although the hydrazine molecule contains two nitrogen atoms, it occupies only a single coordination position because 3-membered rings are unstable (Chugaev's rules). Since one of its nitrogen atoms can still act as an electron pair donor, such a hydrazine complex behaves as a base and reacts with acids:



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Chugaev was also interested in the conversion of Pt(II) complexes to Pt(IV) complexes; he employed hydrogen peroxide (*61*), oxone (*61*), oxygen (*62*), and peroxydisulfate ion (*62*) as oxidizing agents.

In addition to preparing new platinum complexes, Chugaev devised improved methods for the synthesis of known compounds. A case in point is "Cleve's triammine," $[Pt(NH_3)_3Cl]Cl$, for many years the least available of Pt(II) complexes because of its indefinite method of preparation. Chugaev (*63*) was able to synthesize this valuable intermediate from one of the best known Pt(II) complexes, Peyrone's salt, *cis*-$[Pt(NH_3)_2Cl_2]$ (*64*). He also devised a valuable test involving the use of sulfuric acid to distinguish *cis*-$[Pt(NH_3)_2Cl_2]$ from its *trans* isomer (*65*). A novel method utilizing platinum black for the quantitative reduction of K_2PtCl_6 to K_2PtCl_4, a versatile starting material for the synthesis of Pt(II) complexes, (*66*) constituted a great improvement over existing procedures (*67*).

Other Platinum Metals

By use of thiourea, a reagent introduced into platinum chemistry by Kurnakov (*68*), Chugaev was able to prepare a new brilliant red osmium(III) compound, $[Os(NH_2CSNH_2)_6]Cl_3 \cdot H_2O$, analogous to the luteo salts of trivalent Co, Cr, Rh, and Ir. Formation of this compound provided a sensitive analytical test for osmium by means of which one part of osmium can be detected in 100,000 parts of water (*69*). Evidence for the acidic nature of osmium(VIII) oxide was shown by Chugaev's preparation of series of well-defined crystalline compounds, $M_2[OsO_4(OH)_2]$, and unstable compounds, $M_2[OsO_4F_2]$, by reaction of OsO_4 with alkali metal hydroxides or alkali metal fluorides, respectively (*70*). A comprehensive review of Chugaev's work on osmium derivatives from 1916 to 1925 has been given by E. Kh. Fritsman (*71*).

Chugaev's investigations of complexes of palladium with organic monosulfides and disulfides showed these compounds to be intermediate in properties between the corresponding complexes of nickel and platinum (*72*). His studies of hydrazine complexes of iridium led to the discovery of $H[Ir(N_2H_5)Cl_5]$ and its salts (*73a,b*). Ever alert to analytical applications of chemical reactions, Chugaev devised a novel method for detecting iridium in the presence of other platinum metals (sensitivity, 1 part of Ir in 6 million parts of water) based on the oxidation to malachite green of the leuco base of malachite green by $IrCl_6^{2-}$ in acid solution (*73c*).

The scarcity of nonelectrolytic complexes and their crucial importance in the development of coordination chemistry has been mentioned. A series of complex nonelectrolytes of the type $[Rh(NH_3)_3X_3]$, analogous to the corresponding compounds of Co, Cr, and Ir were discovered by Chugaev (*74*). By use of rhodium black at 100°C, Chugaev was able to convert catalytically a mixture of formaldehyde and sodium hydroxide to sodium formate (*75*).

Miscellaneous Works

Some of Chugaev's works which defy classification in the above categories may give an idea of his versatility and wide interests. Among such works are his apparatus for the determination of solubilities at different temperatures (*76*), compounds of univalent nickel (*77*), compounds of aluminum bromide with hydrocarbons (*78*), and studies on the reducing power of sulfurous (*79*) and hyposulfurous acids (*80*). In addition to his two books on coordination chemistry, "O Khimicheskom Stroenii Kompleksnykh Soedinenii" (On the Chemical Structure of Complex Compounds) (1910), and "Strukturno- i Stereokhimicheskie Predstavleniya v Oblasti Neorganicheskoi Khimii. Novye Idei v Khimii" (Structural and Stereochemical Concepts in the Field of Inorganic Chemistry. New Ideas in Chemistry) (1914), Chugaev was the author of two works on the history of chemistry, "Discovery of Oxygen and Theory of Burning" and "Dmitriĭ Ivanovich Mendeleev. Life and Activities."

Chugaev was an outstanding speaker and popularizer of scientific knowledge, and his lectures always attracted large audiences. His skillfully written scientific books and articles contributed in a considerable degree to the dissemination and development of chemical knowledge in the USSR.

Applied Works

Chugaev was no "ivory tower" scientist. During World War I, this versatile chemist, who was later awarded the coveted Lenin Prize by the Soviet government, was one of the initiators of the Voennii-Khimicheskiĭ Komitet (Military Chemical Committee) at the Russkoe Fiziko-Khimicheskoe Obshchestvo (Russian Physical-Chemical Society). At this time he conducted research on medicines and explosives, both sorely needed by a government poorly prepared for the conflict. He also participated actively in the organization and work of the Gosudarstvennyĭ Institut Prikladnoĭ Khimii, GIPKh (State Institute of Applied Chemistry), founded by N. S. Kurnakov (*68*). At the Opytnaia Zavod (Experimental Plant), the first research in Russia on the preparation of red phosphorus, phosphoric anhydride, chromyl chloride, and metallic arsenic was carried out under his direction. In response to an increased demand for platinum catalyst to be used in the contact process for manufacturing sulfuric acid, Chugaev, together with Khlopin and Lebedinskiĭ, devised industrial methods for the refining of platinum and its congeners. He also participated actively in research at the Pishcheviĭ Institut (Nutrition Institute).

The Platinum Institute. In 1915, N. S. Kurnakov, V. I. Vernadskiĭ, and A. E. Fersman organized as part of the Akademiia Nauk (Academy of Sciences), a commission known as Komissiia po Izucheniiu Estestvenno Proizvodstvennykh Sil Rossii, KEPS (Commission for the Study of Russian Natural Productive Sources). In response to this commission's appeal, Chugaev drafted a report in which he argued that platinum, one of Russia's most valuable natural resources, should not be exported in a raw form, but that a state monopoly be created for locating, producing, and processing this important metal. He proposed the formation of an institute with the following functions: comprehensive research on the metals of the platinum group; search for new and useful alloys of these metals;

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systematic study of the coordination compounds of these metals, including a search for new types of such compounds, their syntheses, reactions, and methods for determining their configurations; development and perfection of methods for the refining and analysis of the platinum metals, as well as for the exploitation of low-grade ores.

It was only after the October (1917) Revolution that Chugaev's dream became a reality. In 1918, he was appointed the first director of the newly created Institut po Izucheniiu Platiny i Drugikh Blagorodnykh Metallov (Institute for Study of Platinum and Other Noble Metals) of the Akademiia Nauk S.S.S.R. (Academy of Sciences of the USSR). Members of the staff included N. S. Kurnakov, V. I. Vernadskiĭ, F. Iu. Levinson-Lessing, I. I. Chernyaev, V. G. Khlopin, E. Kh. Fritsman, V. V. Lebedinskiĭ, N. I. Podkopaev, N. I. Stepanov, and N. K. Pshenitsyn as executive administrator. On Chugaev's death in 1922, Kurnakov became director of the Institute.

In accordance with the Soviet policy of creating a Russian chemical literature, the *Izvestiia Instituta po Izucheniiu Platiny i Drugikh Blagorodnykh Metallov* was founded in 1920 by Chugaev in order to publish the Institute's research results. From 1921 to 1935, virtually the entire Russian literature on platinum metals appeared in the 12 volumes of this journal, whose editors were Kurnakov, Fritsman, and Zvyagintsev. In 1934, the Platinum Institute, the Institute of Physicochemical Analysis, and the General Chemistry Laboratory of the Academy of Sciences of the USSR merged into the Institut Obshchei i Neorganicheskoĭ Khimii, IONKh (Institute of General and Inorganic Chemistry), with headquarters in Moscow and with Kurnakov as its director. Beginning with 1936 the journal was renamed *Izvestiia Sektora Platiny i Drugikh Blagorodnykh Metallov;* it ceased publication in 1955, being displaced by the new *Zhurnal Neorganicheskoi Khimii* (Journal of Inorganic Chemistry).

Unfortunately, Chugaev did not live to see the close cooperation which later developed between the Platinum Institute and Russia's platinum industry. Within a comparatively short time after his death in 1922, his ideas concerning the mutual dependence of theory and practice began to materialize, as the Institute rendered substantial aid to the young but growing industry. Even today Chugaev's former students continue to fulfill his prediction that "each and every scientifically founded conclusion or approximation, each pattern which conforms to a rule, each carefully established fact which is concerned with the chemistry of the platinum metals will sooner or later have its practical equivalent."

During his short career, Chugaev created around himself a ranking school of organic chemists among whom may be mentioned F. V. Tserevitinov, G. V. Pigoulevskii, V. A. Fomin, N. A. Schloesinger, and A. A. Glebko. However, it is the "Chugaev School" of inorganic chemists, which includes names such as I. I. Chernyaev, V. G. Khlopin, A. A. Grinberg, V. V. Lebedinskiĭ, and V. K. Pshenitsyn, that has achieved the greater fame. Under Chernyaev's direction, the Institut Obshcheĭ i Neorganicheskoĭ Khimii imeni N. S. Kurnakova Akademii Nauk, S.S.S.R. (N. S. Kurnakov Institute of General and Inorganic Chemistry of the USSR Academy of Sciences), IONKh, today continues the work initiated by Chugaev. The outstanding achievements of this, one of the world's principal centers for the systematic study of coordination compounds, form an enduring testimonial to the genius, foresight, and inspiring influence of Lev Aleksandrovich Chugaev.

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Literature Cited

(1) Lowry, T. M., *J. Chem. Soc.*, **1923**, 956.

(2) Lebedinskiĭ, V. V., *Izv. Sektora Platiny i Drug. Blagorodn. Metal., Inst. Obshch. i Neorgan. Khim., Akad. Nauk S.S.S.R.*, **21**, 18 (1948).

(3) Chugaev, L. A., *Chem. Ber.*, **34**, 1820 (1901); *J. Russ. Phys. Chem. Soc.*, **36**, 1245 (1904).

(4) Chugaev, L. A., and Pokrovskiĭ, V., *J. Russ. Phys. Chem. Soc.*, **41**, 298 (1909).

(5) Chugaev, L. A., *Chem. Ber.*, **32**, 3332 (1899); **33**, 735 (1900); **35**, 2470, 2473 (1902); *J. Russ. Phys. Chem. Soc.*, **35**, 1116 (1903); **36**, 988, 1253 (1904); **39**, 1324 (1907); **42**, 714 (1910); *J. Prakt. Chem.*, [2] **81**, 188 (1910); Chugaev, L. A., and Teearu, P., *Chem. Ber.*, **46**, 1769 (1913).

(6) Chugaev, L. A., *Chem. Ber.*, **33**, 3118 (1900); **34**, 2276 (1901); **37**, 1481 (1904); Chugaev, L. A., and Fomin, V., *Compt. rend.*, **151**, 1058 (1910); *Chem. Ber.*, **45**, 1293 (1912).

(7) Chugaev, L. A., and Budrick, V., *Ann. Chem.*, **388**, 280 (1912); *J. Chem. Soc.*, **1912**, 480.

(8) Chugaev, L. A., and Gastev, A., *Chem. Ber.*, **42**, 4631, (1909); Chugaev, L. A., and Fomin, V., *Compt. rend.* **150**, 1435 (1910); *Ann. Chem.*, **375**, 288 (1910); Chugaev, L. A., and Koch, P., *Ann. Chem.*, **385**, 352 (1911).

(9) Zelinskiĭ, N. D., and Chugaev, L. A., *Chem. Ber.*, **28**, 2940 (1895).

(10) Chugaev, L. A., *Chem. Ber.*, **35**, 3912 (1902).

(11) Chugaev, L. A., and Schloesinger, N. A., *J. Russ. Phys. Chem. Soc.*, **36**, 1258 (1904).

(12) Chugaev, L. A., *Chem. Ber.*, **40**, 186 (1907).

(13) Chugaev, L. A., *Chem. Ber.*, **42**, 49 (1909).

(14) Chugaev, L. A., and Koch, P., *Compt. rend.*, **153**, 259 (1911).

(15) Chugaev, L. A., and Pigoulevskiĭ, G., *Compt. rend.*, **153**, 388 (1911).

(16) Chugaev, L. A., *Chem. Ber.*, **31**, 360, 1775, 2451 (1898); *J. Russ. Phys. Chem. Soc.*, **34**, 606 (1902).

(17) Chugaev, L. A., (*a*) *Chem. Ber.*, **42**, 2244 (1909); (*b*) **44**, 2023 (1911); (*c*) *Z. Physik. Chem.*, **76**, 469 (1911); (*d*) *Bull. Soc. Chim. France*, [4] **11**, 718 (1912); (*e*) [4] **13**, 793 (1913); (*f*) *J. Prakt. Chem.*, [2] **86**, 545 (1912); Chugaev, L. A., and Ogorodnikov, A., (*g*) *Z. Physik. Chem.*, **74**, 503 (1910); (*h*) **79**, 471 (1912); (*i*) *Ann. chim. phys.*, [8] **22**, 137 (1911); Chugaev, L. A., and Glinin, G., (*j*) *Chem. Ber.*, **45**, 2759 (1912); Chugaev, L. A., and

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GLEBKO, A., (*k*) *Chem. Ber.*, **40**, 2752 (1913); CHUGAEV, L. A., AND KIRPICHEV, A., (*l*) *Bull. Soc. Chim. France*, [4] **13**, 796 (1913); CHUGAEV, L. A., AND PASTANOGOV, V., (*m*) *Z. Physik. Chem.*, **85**, 553 (1913).

(18) CHUGAEV, L. A., *Trans. Faraday Soc.*, **10**, 70 (1914).

(19) (*a*) MARTELL, A. E., AND CALVIN, M., "Chemistry of the Metal Chelate Compounds," Prentice-Hall, Inc., New York, 1952; (*b*) BAILAR, J. C., editor, "The Chemistry of the Coordination Compounds," Reinhold Publishing Corp., New York, 1956; (*c*) LEWIS, J., AND WILKINS, R. G., editors, "Modern Coordination Chemistry," Interscience Publishers, Inc., New York, 1960; (*d*) GRINBERG, A. A., "An Introduction to the Chemistry of Complex Compounds," Addison-Wesley Publishing Co., Reading, Mass., 1962.

(20) CHUGAEV, L. A., AND CHESNO, YA. Z., *Trans. Sci. Chem. Pharm. Inst. (Moscow)*, **19**, 181 (1928).

(21) CHUGAEV, L. A., AND SOKOLOV, V., *Chem. Ber.*, **40**, 177, 3461 (1907); **42**, 55 (1909).

(22) CHUGAEV, L. A., *Chem. Ber.*, **37**, 1479 (1904); **38**, 2899 (1905); **39**, 3190 (1906); **40**, 705, 1973 (1907); *J. Russ. Phys. Chem. Soc.*, **38**, 1083 (1906); **41**, 166 (1909).

(23) CHUGAEV, L. A., *J. Russ. Phys. Chem. Soc.*, **38**, 9 (1906); **41**, 253 (1909); *Chem. Ber.*, **40**, 173 (1907).

(24) CHUGAEV, L. A., *Chem. Ber.*, **39**, 3190 (1906); *J. Prakt. Chem.*, [2] **75**, 153 (1907); [2] **76**, 88 (1907).

(25) GRINBERG, A. A., *Helv. Chim. Acta*, **14**, 455 (1931).

(26) CHUGAEV, L. A., *Chem. Ber.*, **41**, 2222 (1908).

(27) CHUGAEV, L. A., AND SERBIN, E., *Compt. rend.*, **151**, 1361 (1910).

(28) CHUGAEV, L. A., *Z. Anorg. Allgem. Chem.*, **46**, 144 (1905); *Chem. Ber.*, **38**, 2520 (1905); **39**, 3382 (1906); **41**, 1678 (1908); *Compt. rend.*, **145**, 679 (1907); *J. Prakt. Chem.*, [2] **75**, 153 (1907); [2] **76**, 88 (1907); *J. Russ. Phys. Chem. Soc.*, **37**, 144 (1905); **38**, 7 (1906); **41**, 184 (1909); **42**, 1466 (1910); *J. Chem. Soc.*, **1914**, 2187; CHUGAEV, L. A., AND SURENJANZ, J., *Chem. Ber.*, **40**, 181 (1907); CHUGAEV, L. A., AND SPIRO, L., *Chem. Ber.*, **41**, 2219 (1908); CHUGAEV, L. A., AND LEBEDINSKIĬ, V. V., *Z. Anorg. Allgem. Chem.*, **83**, 1 (1913); CHUGAEV, L. A., AND GLEBKO, A., *Z. Anorg. Allgem. Chem.*, **89**, 241 (1914).

(29) CHUGAEV, L. A., AND ORELKIN, B., *Z. Anorg. Allgem. Chem.*, **89**, 401 (1914).

(30) WUNDER, M., AND THÜRINGER, V., *Z. Anal. Chem.*, **52**, 101, 660, 740 (1913).

(31) IL'INSKIĬ, M., AND KNORRE, V., *Chem. Ber.*, **18**, 699 (1885).

(32) CHUGAEV, L. A., *Chem. Ber.*, **39**, 2692 (1906); **40**, 3498 (1907); **41**, 2226 (1908); **44**, 1865 (1912).

(33) KAUFFMAN, G. B., J. CHEM. EDUC., **36**, 521 (1959); *Chymia*, **6**, 180 (1960).

(34) PFEIFFER, P., *Chem. Ber.*, **63**, 1811 (1930).

(35) GODYCKI, L. E., AND RUNDLE, R. E., *Acta Cryst.*, **6**, 487 (1953).

(36) GILCHRIST, R., *Chem. Rev.*, **32**, 277 (1943).

(37) CHUGAEV, L. A., AND KHLOPIN, V., *Z. Anorg. Allgem. Chem.*, **86**, 241 (1914); CHUGAEV, L. A., AND IL'IN, S., *Z. Anorg. Allgem. Chem.*, **135**, 143 (1924).

(38) FRITSMAN, E. KH., *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **4**, 55 (1926).

(39) CHUGAEV, L. A., AND SUBBOTIN, V., *Chem. Ber.*, **43**, 1200 (1910).

(40) FRITSMAN, E. KH., AND KRINITSKIĬ, *J. Appl. Chem. U.S.S.R.*, **11**, 1610 (1938); DWYER, F. P., AND NYHOLM, R. S., *J. Proc. Roy. Soc. N. S. Wales*, **79**, 121 (1946); KAUFFMAN, G. B., *Inorg. Syn.*, **7**, 224 (1963); KAUFFMAN, G. B., TSAI, J. H., FAY, R. C., AND JØRGENSEN, C. K., *Inorg. Chem.*, **2**, in press.

(41) CHUGAEV, L. A., AND FRAENKEL, D., *Compt. rend.*, **154**, 33 (1912).

(42) CHUGAEV, L. A., AND PSHENITSYN, N. K., *J. Russ. Phys. Chem. Soc.*, **52**, 47 (1920).

(43) CHUGAEV, L. A., AND BENEVOLENSKIĬ, I., *Z. Anorg. Allgem. Chem.*, **82**, 420 (1913).

(44) CHUGAEV, L. A., AND KOBLINSKIĬ, K., *Z. Anorg. Allgem. Chem.*, **82**, 8 (1913).

(45) CHUGAEV, L. A., AND KHLOPIN, V., *Z. Anorg. Allgem. Chem.*, **82**, 401 (1913).

(46) CHUGAEV, L. A., MALZSHEVSKIĬ, V., AND FRITSMAN, E. KH., *Z. Anorg. Allgem. Chem.*, **135**, 385 (1924); CHUGAEV, L. A., AND FRITSMAN, E. KH., *Z. Anorg. Allgem. Chem.*, **135**, 392 (1924); CHUGAEV, L. A., *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **4**, 146 (1926).

(47) JENSEN, K. A., *Z. Anorg. Allgem. Chem.*, **225**, 97, 115 (1935); KAUFFMAN, G. B., AND COWAN, D. O., *Inorg. Syn.*, **6**, 211 (1960).

(48) CHERNYAEV, I. I., *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **4**, 243 (1926); **5**, 118 (1927); QUAGLIANO, J. V., AND SCHUBERT, L., *Chem. Rev.*, **50**, 201 (1952).

(49) (*a*) CHUGAEV, L. A., AND VLADIMIROV, N., *Compt. rend.*, **160**, 840 (1915); (*b*) CHUGAEV, L. A., *Z. Anorg. Allgem. Chem.*, **137**, 1 (1924); (*c*) *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **4**, 1 (1926).

(50) TEZAK, B., MATIJEVIĆ, E., AND SCHULZ, K. F., *J. Am. Chem. Soc.*, **73**, 1602, 1605 (1951); *J. Phys. Chem.*, **59**, 769 (1955); MATIJEVIĆ, E., BROADHURST, D., AND KERKER, M., *J. Phys. Chem.*, **63**, 1552 (1959); MATIJEVIĆ, E., AND KERKER, M., *J. Phys. Chem.*, **62**, 1271 (1958); "Abstracts of the Seventh International Conference on Coordination Chemistry," Stockholm, Sweden, June 25–29, 1962, pp. 151, 190.

(51) (*a*) CHUGAEV, L. A., AND KHLOPIN, V., *Compt. rend.*, **161**, 699 (1915); (*b*) *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **5**, 85 (1927); (*c*) CHUGAEV, L. A., *Z. Anorg. Allgem. Chem.*, **137**, 401 (1924); (*d*) *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **4**, 37 (1926).

(52) CHUGAEV, L. A., AND CHERNYAEV, I. I., *Compt. rend.*, **161**, 792 (1915).

(53) CHUGAEV, L. A., AND KIL'TYNOVICH, S. S., *J. Russ. Phys. Chem. Soc.*, **47**, 578, 757 (1915); *J. Chem. Soc.*, **1916**, 1286; *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **1**, 70 (1921); CHUGAEV, L. A., AND VLADIMIROV, N. A., *J. Russ. Phys. Chem. Soc.*, **52**, 135 (1920); *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **1**, 86 (1921).

(54) CHUGAEV, L. A., AND ORELKIN, B., *Compt. rend.*, **155**, 1021 (1912); CHUGAEV, L. A., ORELKIN, B., AND FRITSMAN, E. KH., *Z. Anorg. Allgem. Chem.*, **182**, 28 (1929).

(55) CHUGAEV, L. A., AND LEBEDINSKIĬ, V. V., *Compt. rend.*, **161**, 153 (1915); **162**, 43 (1916).

(56) CHUGAEV, L. A., AND TEEARU, P., *Chem. Ber.*, **47**, 568, 2643 (1914); CHUGAEV, L. A., SKANAVIĬ-GRIGORIEVA, M. S., AND POSNYAK, A., *Z. Anorg. Allgem. Chem.*, **148**, 37 (1925); *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **4**, 299 (1926).

(57) CHUGAEV, L. A., AND CHERNYAEV, I. I., *Compt. rend.*, **161**, 637 (1915); *J. Chem. Soc.*, **1918**, 884; *J. Russ. Phys. Chem. Soc.*, **51**, 193 (1920).

(58) CHUGAEV, L. A., AND CHERNYAEV, I. I., *Compt. rend.*, **161**, 792 (1915).

(59) CHUGAEV, L. A., AND KRASIKOV, S. E., *Z. Anorg. Allgem. Chem.*, **131**, 299 (1923); *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **4**, 44 (1926).

(60) CHUGAEV, L. A., *Compt. rend.*, **159**, 188 (1914); CHUGAEV, L. A., AND GRIGORYEV, M., *Chem. Ber.*, **47**, 2446 (1914); CHUGAEV, L. A., AND SKANAVIĬ-GRIGORIEVA, M., *J. Russ. Phys. Chem. Soc.*, **51**, 193 (1920).

(61) CHUGAEV, L. A., AND KHLOPIN, V., *Z. Anorg. Allgem. Chem.*, **151**, 253 (1926).

(62) CHUGAEV, L. A., AND CHERNYAEV, I. I., *Z. Anorg. Allgem. Chem.*, **182**, 159 (1929).

(63) CHUGAEV, L. A., *J. Chem. Soc.*, **1915**, 1247; *J. Russ. Phys. Chem. Soc.*, **47**, 201 (1915); *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **1**, 66 (1921).

(64) KAUFFMAN, G. B., AND COWAN, D. O., *Inorg. Syn.*, **8**, 239 (1963).

(65) CHUGAEV, L. A., *J. Russ. Phys. Chem. Soc.*, **47**, 213 (1915).

(66) CHUGAEV, L. A., *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **7**, 207 (1929).

(67) VÈZÉS, M., *Bull. Soc. Chim. France*, [3] **19**, 879 (1898); KLASON, P., *Chem. Ber.*, **37**, 1360 (1904).

(68) KAUFFMAN, G. B., AND BECK, A., J. CHEM. EDUC., **39**, 44 (1962).

(69) CHUGAEV, L. A., *Compt. rend.*, **167**, 235 (1918); *Bull. Soc. Chim. France*, [4] **23**, 377 (1918); *Z. Anorg. Allgem. Chem.*, **148**, 65 (1925); GILCHRIST, R., *J. Res. Nat. Bur. St.*, **6**, 421 (1931).

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(70) Chugaev, L. A., *Compt. rend.*, 167, 162 (1918).
(71) Fritsman, E. Kh., *Z. Anorg. Allgem. Chem.*, **172**, 213 (1928); Chugaev, L. A., *J. Russ. Phys. Chem. Soc.*, **50**, 294 (1918); **52**, 424 (1920).
(72) Chugaev, L. A., and Ivanov, Ch., *Z. Anorg. Allgem. Chem.*, **135**, 153 (1924).
(73) Chugaev, L. A., (*a*) *Chem. Ber.*, **56**, 2067 (1923); (*b*) *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **4**, 52 (1926); (*c*) *ibid.*, **7**, 205 (1929).
(74) Chugaev, L. A., *Bull. Soc. Chim. France*, [4] **25**, 234 (1919).
(75) Chugaev, L. A., *Izvest. Inst. Izucheniyu Platiny i Drugikh Blagorodnykh Metal.*, **7**, 210 (1929).
(76) Chugaev, L. A., and Khlopin, V. G., *Z. Anorg. Allgem. Chem.*, **86**, 154 (1914); *J. Russ. Phys. Chem. Soc.*, **46**, 1659 (1914).
(77) Chugaev, L. A., and Khlopin, V. G., *Compt. rend.*, **159**, 62 (1914).
(78) Chugaev, L. A., *J. Russ. Phys. Chem. Soc.*, **46**, 1538 (1914).
(79) Chugaev, L. A., and Khlopin, V. G., *Chem. Ber.*, **47**, 1269 (1914).
(80) Chugaev, L. A., and Khlopin, V. G., *J. Russ. Phys. Chem. Soc.*, **47**, 364 (1915).

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JOURNAL ACCOUNT

Receipts:		
Balance, December 31, 2962		$22,390.87
Chemical Educating Publishing Company, share for 1962	$12,408.84	
Total receipts		$34,799.71
Expenditures:		
Dividends transferred to Division Account	$ 1,844.73	
	1,401.37	
Extra pages—1962 Journal	4,786.52	
Purchase of 17 shares ACS Cash and Investment Pool	20,000.00	
Total expenses		$28,032.62
Balance, September 1, 1963		$ 6,767.09
Assets:		
Bank balance, September 1, 1963		$ 6,767.09
U. S. Savings Bonds C 1608-32-3, -4, -5	$ 400.00	
U. S. Savings Bonds M7279936G; M7279064, -6, -7G; M7437661G; M438009, -10G; M399072, -3, -4, -5, -6, -7, -8, -9K	15,000.00	
		15,400.00
ACS Cash and Investment Pool (42 shares purchased 1959, 60, 61, 62, 63; cost: $49,617.48)		
42 shares liquidating value (March 31, 1963)	$52,257.37	
Cash balance (March 31, 1963)	1,142.29	
		53,399.66
Total assets (September 1, 1963)		$75,566.75

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Report of the New England Association of Chemistry Teachers

Official Business

Meetings

Five one-day meetings and a special Twenty-Fifth Anniversary Summer Conference were held during the year 1962–63, under the guidance of President Leallyn B. Clapp of Brown University.

317th Meeting: October 15, 1962, at Laconia Memorial Junior High School, Laconia, N. H. Arranged by Alan H. Davis of Plymouth (N. H.) State College, Chairman of the Northern Division.

318th Meeting: December 1, 1962, at Boston College, Chestnut Hill, Mass. Arranged by David W. Parfitt of Brookline, (Mass.) High School, Chairman of the Central Division.

319th Meeting: February 9, 1963, at Rhode Island College, Providence. Arranged by Robert M. Sherman of Roger Williams Junior College, Providence, Chairman of the Southern Division.

320th Meeting: April 6, 1963, at Central Connecticut State College, New Britain. Arranged by John Prymak of William Hall High School, Hartford, Chairman of the Western Division.

321st Meeting: May 11, 1963, at Clark University, Worcester, Mass. Arranged by David W. Parfitt.

The *Twenty-Fifth Annual Summer Conference* was held August 19–24, at the University of New Hampshire with Alexander R. Amell of the University as the *Host*. Co-Chairmen in charge were: *Program:* Raymond D. Cool, Madison College, Harrisonburg, Va.; *Arrangements:* Maurice Bernier, Exeter (N. H.) High School. The Registrar-Treasurer was Martha Dunbar, Centenary College, Hackettstown, N. J., and the Conference Secretary was Dorothy W. Gifford, Lincoln School, Providence.

In addition to the usual varied and stimulating program, a special trio of speakers were invited for *Twenty-Fifth Anniversary Day:* Dr. William F. Kieffer of the College of Wooster, Wooster, Ohio, Editor of the JOURNAL OF CHEMICAL EDUCATION, who spoke on "The Mole Concept"; Dr. Calvin A. Van der Werf, President of Hope College, Holland, Michigan, who spoke on "Acids and Bases"; and Dr. Edward L. Haenisch, Wabash College, Crawfordsville, Indiana, winner of this year's SAMA Award, who spoke on "Teaching Descriptive Chemistry." Activities of the day were climaxed by "An Evening of Nostalgia" in which photographs of former conferences collected from many sources were presented by Carl Swinnerton of Pomfret, Conn. A silver punch bowl to be used at the evening socials was presented in honor of the six members who have attended all twenty-four previous conferences. Five of these were registered at this conference, completing their first quarter century of faithful attendance:

Mr. and Mrs. Grover C. Greenwood (retired), Bridgeport, Conn.

Mr. Alfred R. Lincoln, Hamden College of Pharmacy, Williamansett, Mass.

Miss Evelyn L. Murdock, Stonington High School, Stonington, Conn.

Miss Elsie S. Scott, Northfield School for Girls, Northfield, Mass.

Appointments and Elections

The officers elected by the membership for the fiscal year 1963–64 have been published in the *Report:* THIS JOURNAL, 40, 440 (1963). As noted there, Harold A. Iddles, Professor of Chemistry at the University of New Hampshire and presently Program Director for the Elementary and College Teachers Program, NSF, was elected to Honorary Membership. He was presented with a certificate at the University where he had served so well as Chairman of the Chemistry Department.

Appointments for the year include:

Editor of the Report: Robert D. Eddy, Tufts University, Medford, Mass.

Editor of the News-Letter: Howard I. Wagner, State Director of Science Education, Concord, N. H.

Assistant Editor of the News-Letter: Angela M. Trovato, Branford High School, Branford, Conn.

Publicity Agent: Everett F. Learnard, Norwood High School, Norwood, Mass.

Twenty-fifth Summer Conference

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New President of NEACT

Guy F. Burrill

Guy Francis Burrill, Chairman of the Science Department and chemistry teacher at Keene (N. H.) High School, took office on July 1, 1963 to become the Association's thirty-sixth President. He earned the BS Degree from the University of New Hampshire in 1937. He was further awarded the MEd degree by the University in 1954. His teaching began at Newport, N. H. in 1931. In 1943–44 he was a Field Director for the American Red Cross, but returned to the classroom in 1944. Since 1960, he has also been the chemistry teacher in the Nurses Training School of the Elliot Hospital in his own community.

Twice he has been Chairman of the Science Division of the New Hampshire Teachers Association. He was on the New Hampshire State Science Fair Committee from 1953–58. He also has been active in NSTA affairs and currently is president of the Keene Education Association. In NEACT, he has assisted in many different capacities, having worked particularly to assure the success of the Summer Conferences.

Guy's summers have not been idle. He was a Research Chemist with the F. A. Putnam Company in 1945, and a General Electric Fellow in 1952. He attended Harvard on a DuPont Scholarship in 1954 and in 1955 was at the Oak Ridge Institute of Nuclear Studies. In 1959 and 1960 he was an Instructor in Chemistry at the Simmons College NSF Institute for Teachers. In 1961 and 1962 he taught chemistry in the Liberal Studies Program at the Mount Herman School for Boys.

Activities

The Association continues to grow with an active membership on September 1 of 1030. In addition, there are 14 honorary members, 33 honorary and active members, and 2 complimentary members. In the sixty-five years since the Association's founding, some 2850 persons have joined our ranks.

During the past year, the largest attendance at a one-day meeting was 125, at Boston College on December 1. A registration of more than 272 members and guests at the Summer Conference made this meeting one of the largest the Association has ever held.

Looking Ahead

The *Twenty-Sixth Summer Conference* will be held in August, 1964, at Colby College, Waterville, Maine. The program will be under the direction of Dorothy W. Gifford of the Lincoln School, Providence, R. I. Alan H. Davis of Plymouth (N. H.) State College will be in charge of arrangements.

ROBERT D. EDDY
Editor, Report of the NEACT

TUFTS UNIVERSITY
MEDFORD, MASSACHUSETTS

Chem Ed

LETTERS

To the Editor:

For the past year I have been making 35-mm slides for lecture use at a cost of about 10 cents a slide in a way which I believe to be simpler than the methods suggested in the article that appeared in the September, 1963 issue, (**40**, 483 (1963)). I use a 35-mm single lens camera with close-up lenses.

The combination of a +2 and a +4 lens permits copying in the range of about 2 × 3 to 9 × 14 in. The lenses and adapters may be purchased for about $10. I do the copying on my desk using a fluorescent desk lamp as the light source. I use 36-exposure (Sears Tower) indoor *color* film with prepaid processing. The advantages of using color film for slide making are: (1) colored subjects can be rendered in color; (2) the slides are positives; and (3) the slides are mounted by the processor at no extra cost. The only disadvantage that this procedure entails is the 1–2 week wait for processing.

RUBIN BATTINO

ILLINOIS INSTITUTE OF TECHNOLOGY
CHICAGO

To the Editor:

The article by F. F. Mikus on "Simple Preparation of Phosphors" (THIS JOURNAL, **40**, 362 (1963)) is much appreciated. His description of $KCl\text{-}SbCl_3$ phosphor prepared at room temperature is an example of a reaction which should be of interest to those who wish to demonstrate or examine solid state reactions. Another such reaction, also carried out under filtered ultraviolet light, is the bright yellow to yellow-green fluorescent system which results when a dry mixture of zinc stearate and 8-hydroxyquinoline (a few tenths to a few per cent of the latter) is gently warmed on a water bath in the presence of ammonia (a small wad of filter paper soaked in NH_4OH and dropped into the mixture suffices). As the ammonia fumes pass through the mixture, the otherwise dull blue fluorescence dramatically changes to the brighter and more vivid emission. The mixture is extremely sensitive to small concentrations and should have possibilities for detecting traces of the gas. The reaction can also be used as a simple and quick method for distinguishing zinc soaps from other metallic soaps.

JACK DE MENT

DEMENT LABORATORIES
PORTLAND, OREGON

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Chem Ed

BOOK REVIEWS

Organic Chemistry

Donald J. Cram, University of California at Los Angeles, and *George S. Hammond*, California Institute of Technology, Pasadena. 2nd ed. McGraw-Hill Book Co., Inc., New York, 1963. Figs. and tables. 17.5 × 28 cm. $10.75.

"If we can get a handle attached to this carbon, a bimolecular substitution ought to give us the alcohol we want without much rearrangement." Anyone who has spent any time in organic research lab has heard comments very similar to that. More and more often, practicing chemists think in terms of substitution, elimination, and addition reactions, etc., and, in fact, many recent very elegant syntheses simply could not have been planned without a detailed understanding of reaction mechanisms.

"We will now discuss the alcohols, considering first methods by which they may be prepared, and then we shall discuss the various reactions which they may be induced to undergo." Anyone who has spent any time in an organic classroom has all too often heard the instructor carry on as if nothing had happened in the past 40 years. Fortunately, in their new edition of "Organic Chemistry," Cram and Hammond continue their practice of encouraging first-rate organic chemists to talk to their students as they talk to each other.

While this text has been extensively revised and rewritten, all of the essential features of the original have been retained (reviewed in J. Chem. Educ., **37**, 325–6, [1960]). The most important of these features is the classification of organic reactions according to mechanism, rather than according to functional group.

As before, the text begins with several chapters on vocabulary, i.e., nomenclature of organic compounds, and some of their more typical reactions. This section now encompasses seven chapters instead of the four previously used, but this has been accomplished not so much by the addition of new material, but rather by a less compressed discussion with more illustrative examples and, primarily, by converting four long chapters into seven shorter, more easily digestible ones. The reactions described have been very carefully selected for their simplicity and use in synthesis and structure proof. Generally this section is excellent but there does seem to be a little confusion as to what happens in a Kuhn-Roth determination (see pp. 42 and 46).

The next four chapters on structure and physical properties have been very considerably revised, expanded, and vastly improved. For example the chapter on the Character of Chemical Bonding has been expanded from 25 to 33 pages and almost completely reorganized. The molecular orbital formulation is presented first, followed by the valence bond method. The chapter is quite remarkable for its clarity and readability, whereas it must be admitted that the student using the first edition needed considerable assistance. The remaining chapters on Stereochemistry, Physical Properties, and Correlation of Structure and Reactivity are less drastically revised.

Chapter 12, which has been almost completely rewritten and much improved, prepares the way for a consideration of the various chemical reactions class by class. The reactions themselves, classified according to mechanism, are discussed in Chapters 13 through 23. Here the most important changes involve the order of presenting the reactions, although new reactions such as hydroboration have been included where appropriate. The chapter on elimination reactions has wisely been moved closer to the front, and a discussion of electrophilic substitution at saturated carbon deferred to Chapter 20. Unfortunately electrophilic substitution at unsaturated carbon still comes pretty late in the game (Chapter 19). The section on radical reactions (chapter 22) is probably the most revised and enlarged (from 12 to 24 pages) one in this section, reflecting the tremendous increase in interest in photochemical reactions.

Following the discussion of the various reactions, a completely new chapter entitled Organic Synthesis appears. This chapter does not present any new material, but does show how an expert artist can design and build the sort of molecule he needs. It is hoped that at least some students will read this chapter for quite a few will appreciate and enjoy it. All teachers will find these pages sheer pleasure.

The remaining nine chapters on special topics are not too much changed from the first edition with the exception of Chapter 31, on spectra. In this chapter the section on dyes has been eliminated and the pages devoted to ultraviolet, infrared, and NMR much expanded. A completely new section on emission spectra has been added.

The problems at the end of each chapter are excellent and more numerous than in the first edition. Also provided are several Reading References but these are usually to standard texts (Ingold, Hine, Gould, Wheland, Fieser and Fieser, Organic Reactions, etc.) and it is regrettable that only in one or two instances is the original literature cited. The admirable practice of citing yields in most reactions is continued.

The type used in this new edition will be particularly clear. The technique of using color in equations to focus the readers attention upon the centers of reactivity is a good idea but it will take some getting used to.

The text should certainly be more "teachable" than the first edition which this writer has used successfully not only with classes of chemistry majors at the junior level but also, with careful choice of chapters, with arts students at the sophomore level. However, one must trust the authors. The natural tendency is to try to expand the "vocabulary" section into a full course and if so one might as well throw away the book. But if taken as directed this text is powerful medicine as well as being lots of fun for both teacher and student.

E. S. Graham
Canadian Services College Royal Roads
Victoria, B.C., Canada

Reviewed in this Issue

Donald J. Cram and *George S. Hammond*, Organic Chemistry
Donald C. Gregg, Principles of Chemistry
C. H. Sorum, Fundamentals of General Chemistry
Robert O. Bolt and *James G. Carroll*, editors, Radiation Effects on Organic Materials
V. Gold, editor, Advances in Physical Organic Chemistry. Volume 1
Sidney Siggia, Quantitative Organic Analysis via Functional Groups
M. F. Grundon and *H. B. Henbest*, The Structures and Reactions of Organic Compounds
Charles Kittel, Elementary Solid State Physics
K. B. Lebedev, The Chemistry of Rhenium
Frank H. Moser and *Arthur L. Thomas*, Phthalocyanine Compounds
Hans Kramer and *Otto Matschoss*, Farben in Kultur und Leben
Harold C. Urey, Some Cosmochemical Problems
Andreas Acrivos, editor, Modern Chemical Engineering. Volume 1, Physical Operations
Trevor Robinson, The Organic Constituents of Higher Plants
Paul Leurgans, editor, Lectures in Materials Science
Marcel Florkin and *Elmer H. Stotz*, editors, Comprehensive Biochemistry. Volume 7, Proteins, Part 1
Marcel Florkin and *Howard S. Mason*, editors, Comparative Biochemistry: A Comprehensive Treatise. Volume 5, Constitutents of Life, Part C
F. F. Nord, editor, Advances in Enzymology. Volume 25
I. M. Kolthoff, and *Philip J. Elving* editors, assisted by *Ernest B. Sandell*, Treatise on Analytical Chemistry. Part 2, Analytical Chemistry of the Elements, Volume 8
R. M. Elliott, editor, Advances in Mass Spectrometry. Volume 2

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Principles of Chemistry

Donald C. Gregg, University of Vermont, Burlington. 2nd ed. Allyn and Bacon Inc., Boston, 1963. xv + 716 + 62 pp. Figs. and tables. 17 × 23.5 cm. $8.50.

The second edition of this textbook is printed in large, easy-to-read type that necessitates more pages for essentially the same number of words. Each chapter, each paragraph, and each sentence appears to have been carefully considered in the revision.

Several changes have been made in the order of topics. The two chapters devoted to the gaseous state in the first edition have been combined into a single chapter which now comes much later in the book. Consideration of atomic structure now begins in the fourth chapter rather than the ninth. Organic chemistry is still the topic of the final chapter, but nuclear chemistry has been moved to the chapter next to the last.

In the treatment of the gaseous state, the measurement of pressure is an example of the kind of topic that has been condensed to make room for topics not formerly considered. The new topics include the equation of state for the ideal gas, the van der Waals equation, the Boltzmann principle, entropy, and the plasma state.

New topics have also been introduced into the discussion of atomic structure and chemical bonding. These include the spatial orientation of atomic orbitals, the hybridization of orbitals, pi and sigma bonds, and stereoisomerism in complex ions. The discussions of geometric isomerism and of optical isomerism in organic chemistry are retained from the first edition.

The equilibrium constant expression is no longer derived by equating rate expressions for the forward and reverse reactions. The treatment of chemical equilibrium is now more thermodynamic, with the discussion involving enthalpy, entropy, and Gibbs free energy.

The only chapters devoted specifically to descriptive chemistry in the first edition were a chapter on oxygen and another on hydrogen. In the new edition there are six chapters of descriptive chemistry entitled Hydrogen, The Oxygen Family, The Halogens, The Nitrogen Family, The Representative Metals, and the Transition Metals.

Gregg retains his practice of using such operational symbols for the elements as $\overline{|Cl}$ so that the electronic formula for hydrogen chloride is written $H\text{-}\overline{Cl|}$ instead of $H:\ddot{Cl}:$ or $H\text{-}\ddot{Cl}:$. He represents the hydrated proton as OH_3^+ and calls it the oxonium ion. He discusses the "unlocalization of electrons" but has discarded the word "resonance." In his treatment of *p*H he has discontinued all mention of *p*OH.

The author has again written a scholarly text and has frequently employed an apt manner of expression, as when he writes: "The atomic weights of the elements are numbers on a scale." It is difficult to understand why he retains the gram-atom, which he uses "to represent the amount of matter in one mole of atoms."

The book is well printed, well bound, well indexed, and well written. The list of suggested readings has been shortened and no longer includes specific journal articles classified according to subject. The 25 photographs of the first edition are missing, but the text is fully illustrated with diagrams. Each chapter is again accompanied by good questions and problems, with answers to problems in the back of the book.

The first edition of this text was published in 1958 and was reviewed in THIS JOURNAL (**37**, 107 [1960]). Meanwhile, the author has written another text entitled "College Chemistry" which was published in 1961 and reviewed in THIS JOURNAL (**39**, A834 [1962]). Although the second edition of "Principles of Chemistry" is organized much like "College Chemistry," the level at which the new book is written is the highest of the three.

LAWRENCE P. EBLIN
Ohio University
Athens

Fundamentals of General Chemistry

C. H. Sorum, University of Wisconsin, Madison. 2nd ed. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1963. 707 pp. Figs. and tables. 17.5 × 24 cm. $8.50.

Readers who are acquainted with the first edition of this freshman textbook (reviewed by Jacob Kleinberg, THIS JOURNAL, **33**, 304 [1956]) will find that the second edition exhibits the careful, logical introduction and development of concepts and the same clear, concise, and readable style which characterized the first. In the new edition, increased emphasis has been given to atomic structure, chemical bonding and molecular geometry, and to redox phenomena. Numerous changes in the order of presentation of topics have also been made.

The first ten chapters are devoted to laying the foundations for, and presenting, the current ideas of atomic structure and chemical bonding. New chapters on Ionization Potential and Chemical Bonding appear in this part. A brief discussion of hybrid orbitals is included. Following chapters on hydrogen and water, comes a section concerned primarily with equilibrium, solutions, and acid-base theory. Redox potentials are discussed next, the Nernst equation being introduced and used. New chapters on Balancing Redox Equations and Chemical Equivalence appear here. Throughout, examples of various types of quantitative calculations are worked out in detail, step by step.

The last third of the book is devoted to descriptive chemistry, the elements being discussed by families, representative elements first, transition elements and the inert gases last. Liberal use is made of oxidation potential data and of tables presenting comparative properties of the elements. A chapter on Complex Ions, dealing with instability constants, structure, and magnetic properties comes early in the discussion of the metals.

A feature of the book which adds greatly to its usefulness is the extensive set of exercises given at the ends of the chapters. These are divided into Questions, Basic Problems, and Advanced Problems, and would appear to challenge students of a wide range in capability.

Despite the care and thoughtfulness evidenced in the organization and writing of this book, it is inevitable that there should be some items to which exception may be taken: The orbital diagram for ethylene, Fig. 9.8, is unclear and indicates a nonplanar structure for this molecule. On p. 311, as an alternative explanation for the behavior of HCl in water, occurs the statement, "It may also be argued that since. . . the water molecule is tetrahedral, the O—H bond between H_2O and HCl is an sp^3 hybrid bond. Since hybridization results in increased bond strength, the O—H bond will be stronger than the nonhybridized H—Cl bond, so the latter will break." One may quarrel, too, with the statements that "*oxidation always involves loss of electrons while reduction always involves gain of electrons*" (p. 367).

In the reviewer's opinion, this book would be admirably suited for use in a substantial introductory college course designed for students who have had some high school chemistry. Able students without such background could use it profitably, too, but might require some supplementing of the first chapter on basic concepts. In any case, the book is designed to *teach* as well as to generate interest.

ERNEST GRISWOLD
University of Kansas
Lawrence

Radiation Effects on Organic Materials

Edited by *Robert O. Bolt* and *James G. Carroll*, California Research Corp., Richmond. Academic Press, Inc., New York, 1963. xv + 576 pp. Figs. and tables. 16.5 × 24 cm. $13.50.

The book is not what its title indicates, namely a treatise on the effect of nuclear radiation on organic matter, but a very thorough and up-to-date treatment of the radiation damage sustained by such organic materials as are commonly used in the construction and operation of nuclear reactors. Because of its high degree of specialization and the restriction to special groups of organic materials, it will not appeal to the student or general scientist as a source of information on a very important subject, but constitutes a most valuable source of information for the specialist, the nuclear scientist or engineer.

The two introductory chapters on Interaction of Radiation with Matter and on Mechanisms of Chemical Effects of Ionizing Radiation written by Amos S. Newton are well written, very concise, and instructive; so is the third introductory chapter on Radiation Chemistry of Pure Compounds, written by the editors. The

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following chapters, all written by eminent experts in their respective field, deal with polymers, plastics, elastomers, coolants, lubricants, adhesives, coatings, dielectric fluids, fuels and shielding materials, coal, wood, and explosives.

While all the discussions in the above-mentioned chapters deal with damaging or deteriorating effects of radiation, the large field of radiation chemistry and radiation-induced beneficial transformation of matter is presented in the last chapter of the book on 10 pages. This is, of course, inadequate to cover the subject matter.

In spite of this high degree of specialization and compartmentalization which makes frequent repetitions unavoidable, the book fulfils two very useful and necessary functions. In the first place it makes comparisons between the data easier by adopting throughout the book a uniform terminology and expressing the most important radiation unit, namely that of absorbed dose, in rads as defined by the International Commission on Radiological Units as 100 ergs per gram of material. And secondly it makes much material accessible otherwise not available through the conventional scientific and technical publications up to 1962.

For these reasons the book will serve as a comprehensive, reliable, and up-to-date reference handbook for all those who need in their work such a well-ordered compilation of data. And the non-specialists who may peruse the volume will get an idea of the great intricacies involved in selecting and protecting materials that are exposed to all kinds of nuclear radiation.

FRANCIS JOSEPH WEISS
Library of Congress
Washington, D. C.

Advances in Physical Organic Chemistry. Volume 1

Edited by *V. Gold*, University of London, England. Academic Press, Inc., New York, 1963. xv + 443 pp. Figs. and tables. 16 × 23.5 cm. $13.

This is the first volume of a new series which aspires to become a recognized medium for the publication of authoritative reviews in physical organic chemistry. This field includes two general areas: studies of reactivity and reaction mechanisms, and studies of physical properties and molecular structure. Although two important books called "Physical Organic Chemistry" are concerned mainly with the former area, Dr. Gold stresses that his series is intended to cover the whole field.

The first three of six chapters of the present volume concern reactivity and mechanisms, and the last three deal with physical properties and structure. Though this reviewer's research is mainly in the former area, he must acknowledge that physical properties and structure have won the field insofar as this book is concerned.

The first chapter, Entropies of Activation and Mechanisms of Reactions in Solution, by W. F. Sager and Stanley L. Long, is disappointing mainly because it is too short. Though it touches on a number of important points, it frequently offers but a few sentences of general comment and then directs the reader to another article or book.

A Quantitative Treatment of Directive Effects in Aromatic Substitution, by L. M. Stock and H. C. Brown, is 120 pages long. Brown's extension of the Hammett $\rho\sigma$ relationship to electrophilic aromatic substitution and certain side chain reactions is presented, but nucleophilic and radical substitutions are ignored. A wealth of data is neatly set forth in tables, but the discussion is tedious and tends to overstate the achievements of Brown and his coworkers.

A. I. Shatenshtein's Hydrogen Isotope Exchange Reactions of Organic Compounds in Liquid Ammonia is valuable because it summarizes a series of researches published mainly in Russia. Perhaps because of a too literal translation, the chapter does not read easily. It seems wordy.

Planar and Non-Planar Aromatic Systems, by G. Ferguson and J. M. Robertson, is a beautifully organized presentation first of methods for detecting deviations from coplanarity, and then of information about a host of specific systems or compounds.

The Identification of Organic Free Radicals by Electron Spin Resonance, by M. C. R. Symons, is a careful and thorough review of this timely subject.

The Structure of Electronically Excited Organic Molecules, by J. C. D. Brand and D. G. Williamson, is mainly concerned with the dozen or so stable organic molecules whose spectra have been analyzed sufficiently to characterize at least one electronically excited state. The chapter is written in the language of the spectroscopist, to which a good introduction is provided.

Every college library should have this book. Purchase is also recommended to individual chemists interested in the field. It is hoped that future volumes will maintain a standard such that the latter statement can be conscientiously repeated.

JOSEPH F. BUNNETT
Brown University
Providence, Rhode Island

Quantitative Organic Analysis via Functional Groups

Sidney Siggia, Olin Mathieson Chemical Corporation, New Haven, Connecticut. 3rd ed. John Wiley and Sons, Inc., New York, 1963. xii + 697 pp. Figs. and tables. 15.5 × 23.5 cm. $19.

The third edition of this book has been lengthened to 697 pages and, therefore, should be reviewed as a new book and not merely as a revision of the second edition. (THIS JOURNAL 31, 558 [1954]).

Dr. Siggia has a reputation for doing a thorough job and this volume is no exception. Each chapter contains a brief historical summary, a discussion of each chemical reaction used for the group, the working procedures presented in full detail, and suitable trace methods for low concentrations. It is pointed out properly that most methods given can be conducted on a microscale if desired.

This volume will receive some criticism because reaction mechanisms and the like are minimized. However, the author indicates in both the preface and the introduction that this is a working book and not a theoretical book.

On the other hand, this volume has much to make its use a necessity in a laboratory doing organic analysis. All of the methods included have been tested in the author's laboratory and as a result minor variations from the literature are to be found. Any competent technician should be able to do the determinations. The chapter on the use of reaction rates to analyze mixtures is a good practical treatment with understandable examples and should become a part of every undergraduate course in analytical chemistry. The chapter on Techniques and Reasoning is a lucid account of the steps in problem-solving.

In a book of this size minor errors are almost impossible to eliminate, so an occasional "burette" and "$Na_2S_2O_2$" for $Na_2S_2O_3$ were not unexpected. The author states that he has selected the methods for utility in his laboratory so some chemists will be surprised to find their contributions overlooked. The printing and binding are excellent.

Most academic and industrial libraries will require this volume, but the price will make it borderline for individuals.

K. G. STONE
Michigan State University
East Lansing

The Structures and Reactions of Organic Compounds: An Introduction

M. F. Grundon and *H. B. Henbest*, both of Queen's University, Belfast, Ireland. Prentice-Hall, Englewood Cliffs, New Jersey, 1962. viii + 208 pp. Figs. and tables. 14.5 × 23.5 cm. $6.

The authors have attempted to present in two hundred pages "the basic ingredients of a modern course in organic chemistry." The problems of choice of topics and how extensively to cover these topics have been handled in a reasonable way in this text. Much more treatment of mechanisms is included than is usual in a book of this type. All too often, however, brevity has been achieved by compression instead of by omission, with the result that some sections would be harder for the student to read than would be corresponding sections in a more extensive text. The difficulty is compounded by the authors' habit of using, without explanation or cross reference, technical terms (such as ester and amine) which they have not yet defined. The literary style sometimes causes further difficulty, as on page 57: "The name *aldehyde* is derived from the words '*al*cohol *deh*ydrogenation,' as acetaldehyde, the first aldehyde to be dis-

(*Continued on page A974*)

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Jan.....1–52, A1–A78
Feb.....53–106, A83–A158
March...107–172, A163–A248
April....173–232, A253–A340
May....233–282, A345–A414
June....283–336, A419–A482
July.....337–390, A487–A540
Aug.....391–444, A545–A602
Sept....345–502, A607–A762
Oct.....503–560, A767–A840
Nov....561–616, A845–A918
Dec.....617–690, A923–A992

ANNUAL INDEX
Journal of Chemical Education
Volume 40, 1963

The annual index for Volume 40 of the Journal of Chemical Education is divided into several parts. Authors are listed in three sections: authors of articles, books reviewed, and letters to the editor. The subject index includes both subjects and titles to articles; the books reviewed are listed in a separate section. The principal subject entries are distinguished from titles by printing the former in italics. Portraits, including medals, are indicated by (P), letters to the editor by (L), errata by (E).

AUTHOR INDEX

ABRÃO, ALCÍDO. Separation and identification of copper in the presence of cadmium..... 413
AFFSPRUNG, H. E.—*See* CHRISTIAN, S. D.
ALLINGER, NORMAN L. Energy relations in teaching organic chemistry..... 201
ALYEA, HUBERT N. TOPS in general chemistry: Tested overhead projection series.
2. Oxygen
C. Reactions with oxygen gas..... A29
D. Some oxidations....A29, A131, A213
E. Ozone..... A213
3. Hydrogen
A. Historical..... A303
B. Preparation..... A303
C. Physical properties.....A383, A459
D. Reactions of hydrogen..... A459
E. Hydrogen isotopes..... A460
4. Water, acids, bases, salts
A. Water.....A635, A813, A885
B. Acids, bases..... A947
Special devices
Inexpensive overhead projector..... A523
Simplified TOPS kit..... A575
Supplementary devices..A30, A131, A213, A304, A383, A460, A814, A886
ANWAR, B.—*See* ANWAR, M. H.
ANWAR, M. H. Separation of plant pigments by thin layer chromatography.. 29
—NORMAN, S., ANWAR, B., AND LAPLACA, P. Electrophoretic study of synthetic food dyes..... 537
ARONSON, JOHN N.—*See* SHAW, WILLIAM H. R.
ASHFORD, T. A. Report from the Examinations Committee..... 114
ASHTON, A. A. Simple method for the preparation of 2,4-dinitroaniline..... 545

BAHE, LOWELL W. Adjusting quiz grades to a common scale..... 90
BAKKER, G. R., BENFEY, O. T., AND STRATTON, W. J. Programing as an aid to effective chemistry teaching..... 18
BALLOU, N. E. Sponsorship of committee on nuclear science—NAS-NRC..... 618
BANKS, JAMES E. The use of programed instruction at the Air Force Academy.. 21
BARTOK, W.—*See* WALLACE, T. J.
BEGEMAN, CHARLES R. Simple evaporator for heat sensitive compounds..... 427
BENFEY, O. T. Concepts of time in chemistry..... 574
—*See* BAKKER, G. R.
BENSON, JOHN E. Viscometric determination of the isoelectric point of a protein. 468
BENT, HENRY A. Tangent-sphere models of molecules.
I. Theory and construction..... 446
II. Uses in teaching..... 523
BHATNAGAR, VIJAY MOHAN. Benzene clathrate..... 646
BLAEDEL, W. J., AND OLSON, C. L. Continuous analysis. Topics in chemical instrumentation..... A549
—*See* OLSEN, EUGENE D.
BORYTA, DANIEL A.—*See* MARKOWITZ, MEYER M.
BOZAK, RICHARD E. Chemistry at Moscow State University..... 376
BRADBURY, J. H. Polymerization kinetics and viscometric characterization of polystyrene. A physical chemistry experiment..... 465
BRADY, A. P.—*See* PASTERNAK, R. A.
BRASTED, ROBERT C. The visiting scientists program in chemistry..... 329
BRECK, W. G. A simple approach to the second law..... 353
BRICKER, CLARK—*See* KEY, PAUL
BRITTON, DOYLE, AND HUGUS, Z Z., JR. Static and kinetic measurements of an equilibrium constant: A physical-inorganic chemistry experiment..... 607
BROCK, W. H. Prout's chemical Bridgewater Treatise..... 652
BROWER, HAROLD E. A glass electrode *p*H meter using a vacuum tube voltmeter.. 85
BRUCE, BECKY—*See* FRIERSON, W. JOE
BUCH, H. A. German chemical and atomic energy documentation centers..... 82
BUNCE, STANLEY C. Project syntheses for organic laboratory courses..... 174
BUTLER, JAMES N. Calculating titration errors..... 66
CAMPBELL, J. A. Kinetics—early and often..... 578
CARLIN, RICHARD L. Electronic spectra of transition metal complexes..... 135
CARNELL, P. H.—*See* REUSCH, R. N.
CARNEY, J. J. Chemical crossword puzzle 496, 522
CARPENTER, GENE B. The use of *n*-center bonds..... 385
CASANOVA, JOSEPH, JR. Student preparation and manipulation of a gas—methyl ethyl ether..... 41
CASSIDY, HAROLD G. The professional presentation of scientific papers..... 373
CHOUDHURY, S. DUTTA—*See* DUTTA, R. L.
CHRISTIAN, S. D., AFFSPRUNG, H. E., JOHNSON, J. R., AND WORLEY, J. D. Control and measurement of water activity..... 419
CHRISTIAN, S. D., AFFSPRUNG, H. E., AND LIN, C. Vapor density apparatus..... 323
CHRISTOPHERSON, HOWARD L. Theoretical titration error: In potentiometric, asymmetrical precipitation titrations.. 63
CLARK, HERBERT M. Criteria for experiments in radiochemistry..... 618
CLEVER, H. LAWRENCE. The hydrated hydronium ion..... 637
CLIFFORD, A. F.—*See* FAETH, PAUL A.
CLUFF, ROBERT B.—*See* SCHELAR, VIRGINIA M.
COHEN, IRWIN, AND FETTEROLF, ROBERT. Programed instruction in the qualitative analysis laboratory..... 25
COHEN, IRWIN—*See* RADLEY, EDWARD T.
CONE, W. H., AND HERMENS, R. A. A simple kinetics experiment for general chemistry laboratory..... 421
CONNICK, ROBERT E. Chemical kinetics in laboratory and classroom..... 587
COWLES, E. J., AND PIKE, M. T. Semimicro modification of the Rast method for determining molecular weights..... 422

DALTON, ROBERT H. Recent developments in glass..... 99
DAS, M. SANKAR—*See* PAREKH, P. P.

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DASENT, W. E. Non-existent compounds.. 130
SCHLEYER, PAUL VON R. (L)..... 270
DAY, JESSE H. Intrinsic programs..14, (L) 229
DELIA, T. J.—*See* VINGIELLO, F. A.
DETHOMAS, A. V.—*See* SHOCK, J. T.
DESSY, RAYMOND E., AND PAULIK, FRANK. Multicenter and assisted mechanistic pathways in the reactions of organometallic compounds, (L) 326..... 185
DEWOLFE, ROBERT H. Kinetics in the study of organic reaction mechanisms.. 95
SONG, PILL-SOON (L)..... 555
DHARMAWARDANE, K. G. A.—*See* DHARMAWARDHANA, M. W. C.
DHARMAWARDHANA, M. W. C., AND DHARMAWARDANE, K. G. A. Rigorous derivation of the kinetic equation for ideal gas pressure..... 318
DILLARD, CLYDE R., AND KAMMEYER, PATTY HALL. An experiment with galvanic cells for the general chemistry laboratory..... 363
DOMÍNGUEZ, X. A., AND LEAL, G. α-Pinene, a starting material for a sequence of organic experiments..... 347
DONOHUE, JERRY. On hydrogen bonds: Textbook errors, 47..... 598
DOUGLASS, IRWIN B. A sobering experience with isopropyl ether peroxide..... 469
DRAKE, G. WILSON. Modified Victor Meyer apparatus..... 606
DRUDING, LEONARD F. TLC separation of ink pigments..... 536
DUNATHAN, HARMON C. The stereochemistry of (−) menthol: An organic laboratory experiment..... 205
DUTTA, R. L., AND CHOUDHURY, S. DUTTA. Noncyanide detection of cadmium..... 414
DUTTON, FREDERIC B., *Editor*. Tested demonstrations..A49, A241, A313, A409, A477, A535, A593, A987

EAKIN, R. F.—*See* OLSEN, EUGENE D.
EDDY, ROBERT D. Official business of the New England Association of Chemistry Teachers..... 666
ELLIS, WILLIAM D. Preparation of diphenylmethane: Simplified procedure: purer product..... 346
EMERSON, G.—*See* PETTIT, R.
EVANS, GORDON G. Stereochemistry in the terminal course..... 438
EYRING, EDWARD M.—*See* LAYTON, RICHARD G.
EYRING, HENRY. Scientific communication. Guest editorial..... 617
—AND MARCHI, R. P. Significant structure theory of liquids..... 562

FAETH, PAUL A., AND CLIFFORD, A. F. Praseodymium oxide-oxygen generator..... 150
FAIRHALL, A. W. Dating of uranium minerals by the specific radioactivity of lead..... 626
FARRIER, D.—*See* VINGIELLO, F. A.
FETTEROLF, ROBERT—*See* COHEN, IRWIN
FIESER, LOUIS F. Plastic Dreiding models..... 457
FINHOLT, JAMES E. A laboratory program in chemical kinetics..... 589
FISCHER, E. Y. Hirshberg—in memoriam.. 112
FORD, RENÉE G. Evaluating a chemistry program..... 16
FOSS, JOHN G. Absorption, dispersion, circular dichroism, and rotary dispersion..... 592
FRAENKEL-CONRAT, H. Ribonucleic acid, the simplest information-transmitting molecule..... 216
FRANKLIN, J. L. The chemical behavior of ions in gases..... 284
FRIERSON, W. JOE, MARABLE, NINA, AND BRUCE, BECKY. A quantitative experiment with paper chromatography.. 408
FULLER, E. C., *Chairman*. Objectives and needs of the Division of Chemical Education..... 223

FYTE, W. S. Modern geochemistry..... 38

GADDIS, SHIRLEY WALTER. Weight burets for the quantitative analysis course... 324
GAIDIS, JAMES M. (*Contributed by* EUGENE G. ROCHOW). The catalyzed decomposition of potassium chlorate..... 78
E. GERALD MEYER AND ELBERT C. WEAVER (L)..... 94
BERNARD JURALE (L)..... 94
GARRETT, ALFRED B. The flash of genius.
12. Radioactive tracers: George de Hevesy..... 36
13. Carbon-14 dating: Willard F. Libby..... 76
14. The positron: C. D. Anderson..... 123
15. Discovery of insulin: Frederick Banting..... 211
16. Quantum theory: Max Planck..... 262
17. Discovery of the transistor: W. Shockley, J. Bardeen and W. Brattain..... 302
GASSMAN, PAUL G.—*See* NEWMAN, MELVIN S.
GATTI, BONNIE M.—*See* TOWNE, JACK C.
GEHMAN, WILLIAM G. Standard ionic crystal structures..... 54
GIBSON, JOHN A., JR.—*See* PAUL, ARMINE D.
GILLESPIE, R. J. The valence-shell electron-pair repulsion (VSEPR) theory of directed valency..... 295
GILMONT, ROGER. Micrometric methods of volume measurement. Topics in chemical instrumentation..... A491
A simple pressure stopcock..... 432
GOLDBERG, DAVID E. Formation constants of a metal-anionic ligand system in dioxane-water..... 341
GOLDHAMER, DAVID—*See* WILSON, ARMIN
GOLDMAN, JAMES A. Potentiometric titration curves for simple ion combination reactions..... 519
GORDON, SAUL. Differential Thermal Analysis. Topics in chemical instrumentation..... A87
GROTZ, LEONARD C. Heterogeneous equilibria in general chemistry..... 479

HAASE, NADINE R. M.—*See* HAYES, KENNETH E.
HAENISCH, EDWARD L. A decade of unusual progress..... 460
HAGAN, MARY MARTINETTE, B.V.M. Clathrates: compounds in cages..... 643
HAGGETT, M. L., JONES, PETER, AND OLDHAM, K. B. Flowing clock reactions... 367
HANRAHAN, ROBERT J. Separatory funnel for successive extraction of the heavier phase..... 69
HANSBURY, ELIZABETH, OTT, D. G., AND PERRINGS, J. D. Thin layer chromatography apparatus..... 31
HAYES, KENNETH E., AND HAASE, NADINE R. M. The thermal stability of H_2Se. Textbook errors, 42..... 149
HAYMAN, H. J. G. Models illustrating rotational isomerism in aliphatic chains..... 208
HEAD, E. L., AND PAVONE, D. Modification of a vacuum desiccator..... 316
HEIN, GEORGE E. The reaction of tertiary amines with nitrous acid..... 181
HERIC, E. L. Conversion grids for ternary systems..... 325
HERMENS, R. A.—*See* CONE, W. H.
HOLMES, ROBERT R. Ionic and molecular halides of the phosphorus family..... 125
HOLT, C. W.—*See* STAFFORD, F. E.
HORNEY, AMOS G. Proposals for significant research in chemistry..... 110
HOVEY, NELSON W. The present and future of qualitative analysis: Report of a survey..... 410
—AND KROHN, ALBERTINE. An evaluation of the Toledo chemistry placement examination..... 370
HUBERTZ, JR.—*See* BRITTON, DOYLE
HUHEEY, JAMES E. Chemistry of diphosphorus compounds..... 153
HUTCHINSON, ERIC, AND TOKIWA, FUMIKATSU. Freezing point observations on micellar solutions..... 472

JAFFÈ, H. H. A classical electrostatic view of chemical forces..... 649
JANZ, G. J.—*See* LORENZ, M. R.
JENSEN, REILLY C.—*See* SHEPPARD, JOHN C.
JOHNSON, J. R.—*See* CHRISTIAN, S. D.
JONES, GEORGE L., JR. A unified quantitative interpretation of two-component phase diagrams..... 38
An enrichment program in chemistry for the advanced high school student..... 605
JONES, PETER, AND OLDHAM, K. B. The theory of the formaldehyde clock reaction..... 366
—See HAGGETT, M. L.
JORDAN, JOSEPH. Thermometric titrators. Topics in chemical instrumentation.... A87
JUSTER, NORMAN J. Conduction and semiconduction..... 489
Organic semiconductors..... 547

KAESZ, HERBERT D. Organometallic derivatives of the transition elements.. 159
KAMEN, MARTIN D. The early history of carbon-14..... 234
KAMMEYER, PATTY HALL—*See* DILLARD, CLYDE R.
KATZ, SAM. A simple thermoregulator.... 266
KAUFFMAN, GEORGE B. Terpenes to platinum: The chemical career of Lev Aleksandrovich Chugaev..... 656
—TAKAHASHI, LLOYD T., AND VICKERY, R. C. The lighter lanthanides: A laboratory experiment in rare earth chemistry..... 433
KELLETT, J. C., JR. A Diels-Alder student preparation..... 543
KENWORTHY, SUSAN, MILLER, JAMES, AND MARTIRE, D. E. Determining activity coefficients by gas chromatography: A physical chemistry experiment..... 541
KESSEL, WILLIAM G. Treasurer's report; Division of Chemical Education of ACS..... 665
KEY, PAUL, SOHL, EDWARD, TIEWS, ROBERT, AND BRICKER, CLARK. Preparation of solutions for qualitative analysis with a cation exchange resin... 416
KING, EDWARD L. Kinetics for the undergraduate: Introduction to the symposium..... 573
KITTSLEY, SCOTT L. An inverted mirror image..... 558
KNUTH, ELDON. A unified kinetic theory description of transport phenomena.... 486
KNYPL, EUGENIUSZ T., AND ZIELEŃSKI, KASIMIERZ. Automatic apparatus for zone refining of organic substances..... 352
KOHMAN, EDWARD F. Who discovered Galvanism?..... 655
KOOYMAN, E. C. Disc-shaped attachments for Dreiding-type molecular models.... 204
KORMENDY, MINERVA F.—*See* LOEV, BERNARD
KRAUS, D. L.—*See* PETROCELLI, A. W.
KROHN, ALBERTINE—*See* HOVEY, NELSON W.
KUPPERS, JAMES R. High capacity vapor traps..... 242

LAGO, R. M., WEI, J., AND PRATER, C. D. Demonstrating the dynamic behavior of coupled systems of chemical reactions..... 395
LALOR, G. C. A reaction vessel for kinetic studies below room temperature..... 597
LAMBERT, FRANK L. Effective teaching of organic chemistry. Guest editorial.... 175
LAPIDUS, J. B.—*See* TYE, A.
LAPLACA, P.—*See* ANWAR, M. H.

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LAUGHLAN, ETHELREDA. Organic chemistry in Ohio high schools 209
LAYTON, RICHARD G., AND EYRING, EDWARD M. Laser experiments in undergraduate physical chemistry laboratory 338
LEAL, G.—*See* DOMÍNGUEZ, X. A.
LEICESTER, HENRY M. Some aspects of the history of chemistry in Russia 108
LEWIN, S. Z., *Editor*. Topics in chemical instrumentation A5, A87, A167, A257, A349, A423, A491, A549, A611, A771, A849, A927
Chromatographic glossary A167
Instrumentation for particle size analysis.
Part 1 ..... A257
Part 2 ..... A349
Part 3 ..... A423
LIN, C.—*See* CHRISTIAN, S. D.
LOEV, BERNARD, SNADER, KENNETH M., AND KORMENDY, MINERVA F. Apparatus for molecular distillation and vacuum sublimation 426
LOGAN, S. R. Catalytic inhibition by adsorbed hydrogen. Textbook errors, 45 473
LORENZ, M. R., AND JANZ, G. J. A dynamic method for measuring dissociation pressures 611
LUBBS, EUGENE K. Device for measuring temperature in a closed rotating flask .. 200

MAHAN, BRUCE H. Temperature dependence of equilibrium: A first experiment in general chemistry 293
MAHLER, J.—*See* PETTIT, R.
MALINS, DONALD C., AND WEKELL, JOHN C. TLC—versatile tool 531
MARABLE, NINA—*See* FRIERSON, W. JOE
MARCH, JERRY. The decarboxylation of organic acids. Textbook errors, 43 212
MARCHI, R. P.—*See* EYRING, HENRY
MARKOWITZ, MEYER M. Alkali metal-water reactions 633
—AND BORYTA, DANIEL A. Uses for rubber eye-dropper bulbs 482
MARSI, KENNETH L., AND WILEN, SAMUEL H. Friedel-Crafts alkylation. Textbook errors, 44 214
MARTIRE, D. E.—*See* KENWORTHY, SUSAN
MASSEY, ALAN G. Uses of electrical discharges in preparative inorganic chemistry 311
MATHUR, PREM BEHARI, AND PAUL, NITYANANDAN J. Magnesium cell for demonstration 43
MCCONNELL, DUNCAN, AND VERHOEK, FRANK H. Crystals, minerals, and chemistry 512
MCCULLOUGH, CSC, BROTHER THOMAS—*See* RADLEY, EDWARD T.
MCGLASHAN, M. L. Deviations from Raoult's law. Textbook errors, 46 516
MCGREER, DONALD E., AND MOCEK, M. M. A qualitative approach to the study of complex NMR spectra 358
MCKAIG, NELSON, JR. Technical report writing in freshman chemistry 86
MCLEAN, JOHN, AND PAUSON, PETER L. A gas chromatography demonstration apparatus 539
MEISLICH, HERBERT. Rules for molecular orbital structures 401
MIKUS, F. F. Simple preparations of phosphors 362
DEMENT, JACK (L) 667
MILLER, DONALD G. Duhem and the Gibbs-Duhem equation 648
MILLER, JAMES—*See* KENWORTHY, SUSAN
MILLER, SIDNEY I.—*See* O'FARRALL, R. A. MORE
MILLIGAN, BARTON. A thermistor actuated proportional temperature controller 263
MOCEK, M. M.—*See* MCGREER, DONALD E.
MOODY, G. J., AND THOMAS, J. D. R. Inorganic reaction mechanisms by iodide ion 151
MYSELS, KAROL J., *Editor*. Textbook errors 149, 212, 214, 473, 516, 598

NAFF, ANNA S.—*See* NAFF, M. BENTON
NAFF, M. BENTON, AND NAFF, ANNA S. TLC on microscope slides. An organic chemistry experiment 534
—AND SPECTOR, WILLIAM. Vacuum distillation with an all glass rotary evaporator 327
NAZARUK, S.—*See* SCHLESINGER, M. D.
NELSON, K.—*See* PUTERBAUGH, W. H.
NEWMAN, MELVIN S., AND GASSMAN, PAUL G. An experimental laboratory course 203
NORMAN, S.—*See* ANWAR, M. H.
NOYES, RICHARD M. Conventions defining thermodynamic properties of aqueous ions and other chemical species 2
Addendum: conventions defining thermodynamics 116
A course in kinetics based on elementary processes 584

O'DONNELL, T. A. A simple separation of the group II-A sulfides 415
OESPER, RALPH E.
—*See* SZABADVÁRY, FERENC
OGRYZLO, E. A., AND PORTER, GERALD B. Contour surfaces for atomic and molecular orbitals 256
OLDHAM, K. B.—*See* JONES, PETER
—*See* HAGGETT, M. L.
OLSEN, EUGENE D., EAKIN, R. F., AND BLAEDEL, W. J. Using tantalum and platinum-clad tantalum electrodes for depositions 320
OLSON, C. L.—*See* BLAEDEL, W. J.
OTT, D. G.—*See* HANSBURY, ELIZABETH

PAREKH, P. P., AND DAS, M. SANKAR. Genetically related radionuclides: Growth-decay studies of ThB-ThC 354
PARIZA, RICHARD. Qualitative detection of Ba, Sr, and Ca ions 417
PASTERNAK, R. A., AND BRADY, A. P. Random and systematic errors in the determination of association constants 254
PATERSON, DAVID A. Abstracting publications on chemical education in the Soviet Union 636
PAUL, ARMINE D., AND GIBSON, JOHN A., JR. Iodide ion as a qualitative reagent: Detection of nitrite and sulfite 417
PAUL, NITYANANDAN J.—*See* MATHUR, PREM BEHARI
PAULIK, FRANK—*See* DESSY, RAYMOND E.
PAULSON, G. L.—*See* STAFFORD, F. E.
PAUSON, PETER L.—*See* MCLEAN, JOHN
PAVONE, D.—*See* HEAD, E. L.
PERRINGS, J. D.—*See* HANSBURY, ELIZABETH
PETERSON, NORMAN C.—*See* SVEC, HARRY J.
PETROCELLI, A. W., AND KRAUS, D. L. The inorganic superoxides 146
PETTIT, R., EMERSON, G., AND MAHLER, J. Chemistry of the diene-iron tricarbonyl complexes 175
PIKE, M. T.—*See* COWLES, E. J.
POLSS, P.—*See* VINGIELLO, F. A.
PORTER, GERALD B.—*See* OGRYZLO, E. A.
POWELL, VIRGINIA P. Programed instruction in high school chemistry 23
PRATER, C. D.—*See* LAGO, R. M.
PUTERBAUGH, W. H., VANSELOW, C. H., NELSON, K., AND SHRAWDER, E. J. Esterification for the introductory organic laboratory course: A modified Dean-Stark trap 349

RADLEY, EDWARD T., COHEN, IRWIN, AND MCCULLOUGH, CSC, BROTHER THOMAS. Mnemonics for thermodynamic equations 261
RAMETTE, RICHARD W. Formation of monothiocyanatoiron(III): A photometric equilibrium study 71
—The dissociation quotient of bromcresol green: A class study of ionic strength effects 252
RATCHFORD, WILLIAM P., AND ROBERTS, NORMAN E. More wealth from agriculture 559
REGGEL, LESLIE—*See* SCHLESINGER, M. D.
REUSCH, R. N. AND CARNELL, P. H. An experimental program on chemical equilibrium 27
RHODES, RICHARD P. High pressure techniques for microscale reactions 423
RICH, RONALD. An approximate wave mechanical treatment of the harmonic oscillator and rigid rotator 365
—Dissolving difficultly soluble salts with chelating ion exchange resins 414
RICHTOL, HERBERT H.—*See* WIBERLEY, STEPHEN E.
ROBERTS, NORMAN E.—*See* RATCHFORD, WILLIAM P.
ROCHOW, EUGENE G.
—*See* GAIDIS, JAMET M.
ROLLINS, CHARLES. Thin layer chromatographic separation of leaf pigments: A rapid demonstration 32
ROTH, BERNICE—*See* SCHELAR, VIRGINIA M.
RUCH, HOLLISTER—*See* ZIEF, MORRIS
RUTLEDGE, T. F.—*See* WEIR, HARRY E.

SCHATZBERG, PAUL. A gas saturation apparatus 267
SCHELAR, VIRGINIA M., CLUFF, ROBERT B., AND ROTH, BERNICE. Placement in general chemistry 369
SCHLESINGER, M. D., NAZARUK, S., AND REGGEL, LESLIE. Laboratory cylinder-mill for small samples 546
SCHNEIDER, RONALD A. Chemical crossword puzzle 268, 333
SCHOENBECK, RALPH, AND TABBUTT, FREDERICK D. An inexpensive spectrograph of moderately high resolution 452
SCHRAMM, CHARLES H.—*See* ZIEF, MORRIS
SCHRIESHIEM, A.—*See* WALLACE, T. J.
SCHUPLE, J. A. Scientific education in Ireland 88
SEBERA, DONALD K. Preparation and analysis of a complex compound 476
SHAW, WILLIAM H. R., AND ARONSON, JOHN N. The preparation of inexpensive lantern slides 483
BATTINO, RUBIN (L) 667
SHEPPARD, JOHN C., AND JENSEN, REILLY C. A radiochemistry experiment: Extraction of cobalt(II) complexes 33
A radiochemistry experiment: The solubility of thallium(I) bromide 34
A radiochemistry experiment: Some chemical properties of neptunium 35
SHEPPARD, WILLIAM J. A Diels-Alder reaction experiment 40
SHRAWDER, E. J.—*See* PUTERBAUGH, W. H.
SIEGEL, BERNARD. Stable gaseous species at high temperatures 304
—Relationship of exothermicities of compounds to chemical bonding 308
—*See* SIEGEL, S.
SIEGEL, S., AND SIEGEL, B. Intrinsic bond energies 143
SIGGIA, SIDNEY. The current prominence of analytical chemistry 604
SIME, RODNEY J. Some models of close packing 61
SKOMOROSKI, R. M. Separation of surface active compounds by foam fractionation 470
SLABAUGH, W. H. Magnetic stirrer: Instrument for the freshman laboratory .. 642
SMITH, NORMAN O. The variation of vapor pressure with total pressure 317

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Digitized by Arya Samaj Foundation Chennai and eGangotri

SNADER, KENNETH. M—*See* LOEV, BERNARD
SOHL, EDWARD—*See* KEY, PAUL
SPECTOR, WILLIAM—*See* NAFF, M. BENTON
STAFFORD, F. E., HOLT, C. W., AND PAULSON, G. L. Vibration-rotation spectrum of HCl: A physical chemistry experiment 245
Heat of vaporization of I_2 using absolute entropy data: A physical chemistry experiment 249
STEELINK, CORNELIUS. What is humic acid? 379
STOCK, J. T., AND DETHOMAS, A. V. A "direct attachment" Kjeldahl apparatus 87
STRATTON, W. J.—*See* BAKKER, G. R.
SUSSMAN, M. V. Maxwell's demon demonstrator 49
SUTER, RUFUS. Naming chemical elements in Chinese 44
CHANG, J. C. (L) 388
TUNG, CHEN TA (L) 388
WU, CHISUNG (L) 388
SVEC, HARRY J., AND PETERSON, NORMAN C. Constant current power supply 37
SZABADVÁRY, FERENC (RALPH E. OESPER, *Translator*). The early history of chemistry in Hungary 46

TABBUTT, FREDERICK D.—*See* SCHOENBECK, RALPH
TAKAHASHI, LLOYD T.—*See* KAUFFMAN, GEORGE B.
TAYLOR, JOHN K.—*See* YOUNG, JAY A.
TEE, PETER A. H., AND TONGE, BRIAN L. The physical and chemical character of graphite 117
THOMAS, E. B. Graphical treatment simplifies acid-base equilibria calculations 70
THOMAS, J. D. R.—*See* MOODY, G. J.
TIETZE, H. R. Some experiments on the stoichiometry of reactions 344
TIEWS, ROBERT—*See* KEY, PAUL
TOKIWA, FUMIKATSU—*See* HUTCHINSON, ERIC
TOLPIN, J. G. Using Russian technical information 430
TONGE, BRIAN L.—*See* TEE, PETER, A. H.
TOWNE, JACK C., AND GATTI, BONNIE M. Demonstration of radioautography and paper chromatography using a Polaroid camera 243
TRAYNHAM, JAMES G. The bromonium ion 392
TRUMBULL, ELMER R. A simple closed end manometer 350
TRUSELL, FRED. William Allen Miller: Pioneer stellar spectroscopist 612
TYE, A., AND LAPIDUS, J. B. A simple model to illustrate conformational effects in acyclic molecules 28

VANLANDINGHAM, JOHN W. Inorganic nutrients in the sea 272
VANSELOW, C. H.—*See* PUTERBAUGH, W. H.
VASLOW, FRED. A simple condensation isotherm for a hard sphere gas 485
VERHOEK, FRANK H.—*See* MCCONNELL, DUNCAN
VICKERY, R. C.—*See* KAUFFMAN, GEORGE B.
VINGIELLO, F. A., DELIA, T. J., POLSS, P., AND FARRIER, D. An improved synthesis of 2-bromonaphthalene 544
VOLLMER, ROBERT. Beam protective device for an automatic analytical balance 77

WALLACE, T. J., BARTOK, W., AND SCHRIESHIEM, A. A convenient synthetic technique to oxidize mercaptans to disulfides 39
WARD, ROLAND. Would Mendeleev have predicted the existence of XeF_4? 277
WEI, J.—*See* LAGO, R. M.
WEIR, HARRY E., AND RUTLEDGE, T. F. A small fluidized-solid constant temperature bath 425
WEISSLER, JOHN C.—*See* MALINS, DONALD C.
WENDLANDT, WESLEY W. Vacuum and controlled atmosphere differential thermal analysis apparatus 428
WEST, JOSEPH A. The chemistry of enamines 194
WHITAKER, ROBERT D. A kinetics experiment for the physical chemistry laboratory 264
WIBERLEY, STEPHEN E., AND RICHTOL, HERBERT H. Emission Spectroscopy. Topics in chemical instrumentation A927
WIEGAND, JAMES H. Demonstrating the Wiessenberg effect with gelatin 475
WILEN, SAMUEL—*See* MARSI, KENNETH L.
WILSON, ARMIN, AND GOLDHAMER, DAVID. Cyclobutane chemistry
1. Structure and strain energy 504
2. Reactions and mechanisms 599
WISE, EDWARD N. A modular approach to chemical instrumentation 73
WORLEY, J. D.—*See* CHRISTIAN, S. D.
WRIGHT, JOHN C. An undergraduate organic experiment with carbon-14 206

YOUNG, JAY A. Introduction: Programed instruction. Symposium 11
Both can benefit, student and teacher 11
—AND TAYLOR, JOHN K. Chemical projects: Research ideas for young chemists A44, A135, A186, A306, A386, A463, A538, A564, A888, A986

ZENCHELSKY, SEYMOUR T. Pressure Measurement. Topics in chemical instrumentation.
Part 1 ..... A611
Part 2 ..... A771
Part 3 ..... A849
ZIEF, MORRIS, RUCH, HOLLISTER, AND SCHRAMM, CHARLES H. Low temperature zone refining apparatus 351
ZIELEŃSKI, KASIMIERZ—*See* KNYPL, EUGENIUSZ T.
ZIMMERMAN, HOWARD K. Method for determining order of a reaction 356

SUBJECT INDEX

Absorption, dispersion, circular dichroism, and rotary dispersion. JOHN G. FOSS 592
Abstracting publications on chemical education in the Soviet Union. DAVID A. PATERSON 636
Acid-base equilibria calculations, Graphical treatment simplifies. E. B. THOMAS 70
Acids, The decarboxylation of organic. Textbook errors, 43. JERRY MARCH 213
Activity coefficients by gas chromatography, Determining: A physical chemistry experiment. SUSAN KENWORTHY, JAMES MILLER, AND D. E. MARTIRE 541
Activity, Control and measurement of water. S. D. CHRISTIAN, H. E. AFFSPRUNG, J. R. JOHNSON, AND J. D. WORLEY 419
Adjusting quiz grades to a common scale. LOWELL W. BAHE 90
Adsorbed hydrogen, Catalytic inhibition by. Textbook errors, 45. S. R. LOGAN 473
Agriculture, More wealth from. WILLIAM P. RATCHFORD AND NORMAN E. ROBERTS 556
Air Force Academy, The use of programed instruction at the. JAMES E. BANKS 21
Aliphatic chains, Models illustrating rotational isomerism in. H. J. G. HAYMAN 208
Alkali metal-water reactions. MEYER M. MARKOWITZ 633
Alkylation, Friedel-Crafts. Textbook errors, 44. KENNETH L. MARSI AND SAMUEL H. WILEN 215
Amines, The reaction of tertiary, with nitrous acid. GEORGE E. HEIN 181
Analytical balance, automatic, Beam protective device for. ROBERT VOLLMER 77
Analytical chemistry
Acid-base equilibria calculations 70
Formation constants experiment 341
Ionic strength effects 252
Modular instruments 73
Monothiocyanatoiron(III) equilibrium 71
Organic experiments 93
Potentiometric titrations 519
Qualitative notes 413
Quantitative paper chromatography 408
Rare earths 433
Reaction mechanism technique 151
Semimicro Rast method 422
Simple weight burets 324
Spectrograph construction and experiment 452
Stoichiometry experiments 344
Structure and chromatography 229
Tantalum electrodes 320
Tertiary amines 181
Titration error 63, 66
Analytical chemistry, The current prominence of. SIDNEY SIGGIA 604
Anderson, C. D.: The positron. The flash of genius, 14. ALFRED B. GARRETT 123
Anthropomorphism
Editorially speaking 561
Apparatus
Closed end manometer 350
Constant current power supply 37
Cylinder-mill 546
Dean-Stark trap 349
Dissociation pressures 611
Fluidized bath 425
Gas chromatography demonstration 539
Gas saturation 267
Glass rotary evaporator 327
High capacity vapor traps 242
High pressure 423

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Modified Kjeldahl 87
Modular instruments 73
Molecular distilation 426
Oxidation of mercaptans to disulfides 39
Oxygen generator 150
pH meter 85
Pressure stopcock 432
Protective device for balances 77
Reaction vessel 597
Rotary evaporator 427
Separatory funnel modification 69
Simple magnetic stirrer 642
Simple weight burets 324
Spectrograph construction 452
Tantalum electrodes 320
Temperature measurement in a closed flask 200
Thermistor temperature controller 263
Thermoregulator 266
Thin layer chromatography 31, 531, 534, 536
Using eye-dropper bulbs 482
Vacuum desiccator 316
Vacuum differential thermal analysis 428
Vapor density 323
Victor Meyer 606
Zone refining 351, 352

Apparatus for molecular distillation and vacuum sublimation. BERNARD LOEV, KENNETH M. SNADER, AND MINERVA F. KORMENDY 426
Approximate wave mechanical treatment of the harmonic oscillator and rigid rotator, An. RONALD RICH 365
Association constants, Random and systematic errors in the determination of. R. A. PASTERNAK AND A. P. BRADY 254
Atomic and molecular orbitals, Contour surfaces for. E. A. OGRYZLO AND GERALD B. PORTER 256
Automatic apparatus for zone refining of organic substances. EUGENIUSZ T. KNYPL AND KASIMIERZ ZIELENSKI 352

Award addresses
Dexter award. HENRY M. LEICESTER 108
Nuclear chemistry. M. D. KAMEN 234
SAMA award. EDWARD L. HAENISCH 460
Southwest ACS. J. L. FRANKLIN 284

Balance, automatic analytical, Beam protective device for. ROBERT VOLLMER 77

Balancing equations
Algebraic method 269

Banting, Frederick: Discovery of insulin. The flash of genius, 15. ALFRED B. GARRETT 211
Bardeen, J., Brattain, W., and Shockley, W.: The discovery of the transistor. The flash of genius, 17. ALFRED B. GARRETT 302
Ba, Sr, and Ca ions, Qualitative detection of. RICHARD PARIZA 417
Bath, A small fluidized-solid constant temperature bath. HARRY E. WEIR AND T. F. RUTLEDGE 425
Beam protective device for an automatic analytical balance. ROBERT VOLLMER 77

Biochemistry
Discovery of insulin 211
Humic acid 379
Isoelectric protein experiment 468
Ribonucleic acid 216

Biography
Anderson, C. D. 123
Banting, Frederick 211
Brasted, Robert C. 271
Bricker, Clark E. 271
Buckingham, John H. 271
Chugaev, Lev Aleksandrovich 666
de Hevesy, George 36
Galvani, Luigi 655
Harrison, Anna J. 271
Hirshberg, Y. 112
Jones, William H. 271
Kamen, M. D. 234
Kessel, William G. 271
Libby, Willard F. 76
Miller, William Allen 612
Prout, William 652
Ruprecht, Anatole 47

Blaedel, W. J. (P) A549

Bond energies
Calculations from high temperature behavior 304

Bond energies, Intrinsic. B. SIEGEL AND S. SIEGEL 143

Bonding
Electrostatic forces 649
n-Center 385
Non-existent compounds ..... 130, (L) 270
Organometallics 159

Bonding, chemical, Relationship of exothermicities of compounds to. BERNARD SIEGEL 308
Bonds, The use of *n*-center GENE B. CARPENTER 385
Both can benefit, student and teacher. JAY A. YOUNG 11
Brattain, W., Shockley, W., and Bardeen, J.: The discovery of the transistor. The flash of genius, 17. ALFRED B. GARRETT 302
Bridgewater Treatise, Prout's chemical. W. H. BROCK 652
Bromcresol green, The dissociation quotient of: A class study of ionic strength effects. RICHARD W. RAMETTE 252
2-Bromonaphthalene, An improved synthesis of. F. A. VINGIELLO, T. J. DELIA, P. POLSS, AND D. FARRIER 544
Bromonium ion, The. JAMES G. TRAYNHAM 392
Bulbs, Uses for rubber eye-dropper. MEYER M. MARKOWITZ AND DANIEL A. BORYTA 482
Burets, weight, for the quantitative analysis course. SHIRLEY WALTER GADDIS 324

Cadmium, Non-cyanide detection of. R. L. DUTTA AND S. DUTTA CHOUDHURY 414
Cadmium, Separation and identification of copper in the presence of. ALCÍDIO ABRAO 413
Calculating titration errors. JAMES N. BUTLER 66
Calculations, Graphical treatment simplifies acid-base equilibria. E. B. THOMAS 70

California Association of Chemistry Teachers:
Articles
Conduction and semiconduction. NORMAN J. JUSTER 489
Inorganic nutrients in the sea. JOHN W. VAN LANDINGHAM 272
Kinetics in the study of organic reaction mechanisms. ROBERT H. DEWOLFE 95
SONG, PILL-SOON (L) 555
Lighter lanthanides, The: A laboratory experiment in rare earth chemistry. GEORGE B. KAUFFMAN, T. LLOYD TAKHASHI, AND R. C. VICKERY 433
Modern geochemistry. W. S. FYFE 330
Organic semiconductors. NORMAN J. JUSTER 547
Organometallic derivatives of the transition elements. HERBERT D. KAESZ 159
Ribonucleic acid, the simplest information-transmitting molecule. H. FRAENKEL-CONRAT 216
Terpenes to platinum: The chemical career of Lev Aleksandrovich Chugauv. GEORGE B. KAUFFMAN 656
What is humic acid? CORNELIUS STEELINK 379
CACT fifth summer conference 222, 276

Carbon-14, An undergraduate organic experiment. JOHN C. WRIGHT 206
Carbon-14 dating: Willard F. Libby. The flash of genius, 13. ALFRED B. GARRETT 76
Carbon-14, The early history of. MARTIN D. KAMEN 234
Catalytic inhibition by adsorbed hydrogen. Textbook errors, 4. S. R. LOGAN 473
Catalyzed decomposition of potassium chlorate, The. JAMES M. GAIDIS (*Contributed by* EUGENE G. ROCHOW) 78
E. GERALD MEYER AND ELBERT C. WEAVER (L) 94
BERNARD JURALE (L) 94
Cation exchange resin, Preparation of solutions for qualitative analysis with a. PAUL KEY, EDWARD SOHL, ROBERT TIEWS, AND CLARKE BRICKER 416
Cell, Magnesium, for demonstration. PREM BEHARI MATHUR AND NITYANANDAN J. PAUL 43
n-Center bonds, The use of. GENE B. CARPENTER 385
Chelating ion exchange resins, Dissolving difficulty soluble salts with. RONALD RICH 414
Chem gems 81, 251, 255, 384, 538
Chemical and atomic energy documentation centers, German. H. A. BUCH 82
Chemical behavior of ions in gases, The. J. L. FRANKLIN 284
Chemical crossword puzzle. RONALD A. SCHNEIDER 268, 333
J. J. CARNEY 496, 522
Chemical forces, A classical electrostatic view of. H. H. JAFFÉ 649
Chemical instrumentation, Topics in. S. Z. LEWIN, *Editor*
V. Thermometric titrators A5
VI. Differential thermal analysis A87
VII. Chromatography glossary A167
VIII. Instrumentation for particle size analysis. Part 1 ..... A257
Part 2 ..... A349
Part 3 ..... A423
IX. Micrometric methods of volume measurement A491
X. Emission spectroscopy A927
XI. Continuous analysis A549
XII. Pressure measurement, Part 1 ..... A611
Part 2 ..... A771
Part 3 ..... A849

Chemical kinetics in laboratory and classroom. ROBERT E. CONNICK 587

Chemical literature
Beilstein Institute 82
Chemical education in the Soviet Union 636
Chinese chemical names 44
Chang, J. C. (L) 388
Tung, Chen Ta (L) 388
Wu, Chisung (L) 388
German documentation centers 82
Gmelin Institute 82
Thermodynamic conventions 2
Using Russian technical information 430

Chemical projects: Research ideas for young chemists. JAY A. YOUNG AND JOHN K. TAYLOR
Inorganic A44, A135, A186
Organic A463, A986
Physical A386, A538, A888
Qualitative A564
Quantitative A306, A888, A986

Chemical publications in liberal arts college 228
Chemiluminescence in electrolysis. Tested demonstration A477
Chemistry at Moscow State University. RICHARD E. BOZAK 376
Chemistry, Concepts of time in. O. T. BENFEY 574
Chemistry of diphosphorus compounds. JAMES E. HUHEEY 153
Chemistry of enamines, The. JOSEPH A. WEST 194
Chemistry of the diene-iron tricarbonyl complexes. R. PETTIT, G. EMERSON, AND J. MAHLER 175
Chemistry program, Evaluating a. RENEÉ G. FORD 16
Chinese, Naming chemical elements in. RUFUS SUTER 44
Chang, J. C. (L) 388
Tung, Chen Ta (L) 388
Wu, Chisung (L) 388
Chromatographic glossary. Topics in chemical instrumentation. S. Z. LEWIN, *Editor* A167

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Chromatographic, Thin layer, separation of leaf pigments: A rapid demonstration. CHARLES ROLLINS ... 32
Chromatography
Structure and migration rate ... 229
Chromatography, A quantitative experiment with paper. W. JOE FRIERSON, NINA MARABLE, AND BECKY BRUCE ... 408
Chromatography demonstration apparatus, A gas. JOHN MCLEAN AND PETER L. PAUSON ... 539
Chromatography, paper, using a Polaroid camera, Demonstration of radioautography and. JACK C. TOWNE AND BONNIE M. GATTI ... 243
Chromatography. Tested demonstration ... A535
Chromatography, Thin layer, apparatus. ELIZABETH HANSBURY, D. G. OTT, AND J. D. PERRINGS ... 31
Chromatography, thin layer, Separation of plant pigments by. M. H. ANWAR ... 29
Chugaev, Lev Aleksandrovich (P) ... 656
Chugaev, The chemical career of Lev Aleksandrovich: Terpenes to platinum. GEORGE B. KAUFFMAN ... 656
Circular dichroism, and rotary dispersion, Absorption, dispersion. JOHN G. FOSS ... 592
Classical electrostatic view of chemical forces, A. H. H. JAFFÉ ... 649
Clathrate, Benzene. VIJAY MOHAN BHATNAGAR ... 646
Clathrates: Compounds in cages. MARY MARTINETTE HAGAN, B.V.M. ... 643
Clock reaction, The theory of the formaldehyde. PETER JONES AND K. B. OLDHAM ... 366
Clock reactions, Flowing. M. L. HAGGETT, PETER JONES, AND K. B. OLDHAM ... 367
Close packing, Some models of. RODNEY J. SIME ... 61
Cobalt(II) complexes, Extraction of: A radiochemistry experiment. JOHN C. SHEPPARD AND REILLY C. JENSEN ... 33
Colloid chemistry
Demonstrating Weissenberg effect ... 475
Foam fractionation experiment ... 470
Isoelectric point experiment ... 468
Observations on micellar solutions ... 472
Polymer experiment ... 465
Complex compound, Preparation and analysis of a. DONALD K. SEBERA ... 476
Complexes, Chemistry of the diene-iron tricarbonyl. R. PETTIT, G. EMERSON, AND J. MAHLER ... 175
Complexes, cobalt(II), Extraction of: A radiochemistry experiment. JOHN C. SHEPPARD AND REILLY C. JENSEN ... 33
Complexes, transition metal, Electronic spectra of. RICHARD L. CARLIN ... 135
Compounds, Non-existent. W. E. DASENT 130
SCHLEYER, PAUL VON R. (L) ... 270
Concepts of time in chemistry. O. T. BENFEY ... 574
Condensed norms: ACS cooperative examinations. Division of Chemical Education ... 115
Condensed norms
Graduate placement analytical ... 115
Graduate placement organic ... 115
Graduate placement physical ... 116
Organic form 1962 ... 116
Conduction and semiconduction. NORMAN J. JUSTER ... 489
Conformational analysis
Plastic Dreiding models ... 457
Tangent-sphere models ... 446, 523
Conformational effects in acyclic molecules, A simple model to illustrate. A. TYE AND J. B. LAPIDUS ... 28
Constant current power supply. HARRY J. SVEC AND NORMAN C. PETERSON ... 37
Constants, Formation, of a metal-anionic ligand system in dioxane-water. DAVID E. GOLDBERG ... 341
Constants, physical, National Bureau of Standards values for ... 642
Continuous analysis. Topics in chemical instrumentation. W. J. BLAEDEL AND C. L. OLSON ... A549
Contour surfaces for atomic and molecular orbitals. E. A. OGRYZLO AND GERALD B. PORTER ... 256
Control and measurement of water activity. S. D. CHRISTIAN, H. E. AFFSPRUNG, J. R. JOHNSON, AND J. D. WORLEY ... 419
Controller, temperature, A thermistor actuated proportional. BARTON MILLIGAN ... 263
Convenient synthetic technique to oxidize mercaptans to disulfides, A. T. J. WALLACE, W. BARTOK, AND A. SCHRIESHEIM ... 39
Conventions defining thermodynamic properties of aqueous ions and other chemical species. RICHARD M. NOYES ... 2
Addendum ... 116
Conversion grids for ternary systems. E. L. HERIC ... 325
Coordination chemistry
Contributions of Lev Aleksandrovich Chugaev ... 656
Synthesis experiment ... 476
Copper in the presence of cadmium, Separation and identification of. ALCÍDIO ABRÃO ... 413
Coupled systems of chemical reactions, Demonstrating the dynamic behavior of. R. M. LAGO, J. WEI, AND C. D. PRATER ... 395
Course in kinetics based on elementary processes, A. RICHARD M. NOYES ... 584
Criteria for experiments in radiochemistry. HERBERT M. CLARK ... 618
Crossword puzzle, Chemical. J. J. CARNEY ... 496, 522
RONALD A. SCHNEIDER ... 268, 333
Crystal field theory
Spectra of complexes ... 135
Crystal structure
Close packing ... 61
Crystal structures, Standard ionic. WILLIAM G. GEHMAN ... 54
Crystal, minerals, and chemistry. DUNCAN MCCONNELL AND FRANK H. VERHOEK ... 512
Current prominence of analytical chemistry, The. SIDNEY SIGGIA ... 604
Curriculum
Prominence of analytical chemistry ... 604
Cyclobutane chemistry. 1. Structure and strain energy. ARMIN WILSON AND DAVID GOLDHAMER ... 504
2. Reactions and mechanisms ... 599
Cylinder-mill for small samples, Laboratory. M. D. SCHLESINGER, S. NAZARUK, AND LESLIE REGGEL ... 546

Dating of uranium minerals by the specific radioactivity of lead. A. W. FAIRHALL 626
Dean-Stark trap, A modified: Esterification for the introductory organic laboratory course. W. H. PUTERBAUGH, C. H. VANSELOW, K. NELSON, AND E. J. SHRAWDER ... 349
Decade of unusual progress, A. EDWARD L. HAENISCH ... 460
Decarboxylation of organic acids, The. Textbook errors, 43. JERRY MARCH ... 212
Decomposition of potassium chlorate, The catalyzed. JAMES M. GAIDIS (*Contributed by* EUGENE G. ROCHOW) ... 78
E. GERALD MEYER AND ELBERT C. WEAVER (L) ... 94
BERNARD JURALE (L) ... 94
Defining, Conventions, thermodynamic properties of aqueous ions and other chemical species. RICHARD M. NOYES 2
Addendum ... 116
de Hevesy, George: Radioactive tracers. The flash of genius 12. ALFRED B. GARRETT ... 36
Demonstrating the dynamic behavior of coupled systems of chemical reactions. R. M. LAGO, J. WEI, AND C. D. PRATER ... 395
Demonstrating the Weissenberg effect with gelatin. JAMES H. WIEGAND ... 475
Demonstration apparatus, A gas, chromatography. JOHN MCLEAN AND PETER L. PAUSON ... 539
Demonstration, A rapid: Thin layer chromatographic separation of leaf pigments. CHARLES ROLLINS ... 32
Demonstration notes. Tested demonstrations ... A241
Demonstration of radioautography and paper chromatography using a Polaroid camera. JACK C. TOWNE AND BONNIE M. GATTI ... 243
Depositions, Using tantalum and platinum-clad tantalum electrodes for. EUGENE D. OLSEN, R. F. EAKIN, AND W. J. BLAEDEL ... 320
Derivation of the kinetic equation for ideal gas pressure, Rigorous. M. W. C. DHARMAWARDHANA AND K. G. A. DHARMAWARDANE ... 318
Desiccator, vacuum, Modification of a. E. L. HEAD AND D. PAVONE ... 316
Determining activity coefficients by gas chromatography: A physical chemistry experiment. SUSAN KENWORTHY, JAMES MILLER, AND D. E. MARTIRE ... 541
Deviations from Raoult's law. Textbook errors, 46. M. L. MCGLASHAN ... 516
Device for measuring temperature in a closed rotating flask. EUGENE K. LUBBS ... 200
Diels-Alder reaction experiment, A. WILLIAM J. SHEPPARD ... 40
Diels-Alder student preparation, A. J. C. KELLETT, JR. ... 543
Diene-iron tricarbonyl complexes, Chemistry of the. R. Pettit, G. Emerson, AND J. MAHLER ... 175
Differential thermal analysis apparatus, Vacuum and controlled atmosphere. WESLEY W. WENDLANDT ... 428
Differential thermal analysis. Topics in chemical instrumentation. SAUL GORDON ... A87
2,4-Dinitroaniline, Simple method for the preparation of. A. A. ASHTON ... 545
Diphenylmethane, Preparation of: Simplified procedure: purer product. WILLIAM D. ELLIS ... 346
Diphosphorus compounds, Chemistry of. JAMES E. HUHEEY ... 153
"Direct attachment" Kjeldahl apparatus, A. J. T. STOCK AND A. V. DETHOMAS ... 87
Directed valency, The valence-shell electron-pair repulsion (VSEPR) theory of. R. J. GILLESPIE ... 295
Discharges, electrical, in preparative inorganic chemistry, Uses of. ALAN G. MASSEY ... 311
Discovery of insulin: Frederick Banting. The flash of genius, 15. ALFRED B. GARRETT ... 211
Discovery of the transistor: W. Shockley, J. Bardeen and W. Brattain. The flash of genius, 17. ALFRED B. GARRETT ... 302
Disc-shaped attachments for Dreiding-type molecular models. E. C. KOOYMAN ... 204
Dispersion, circular dichroism, and rotary dispersion, Absorption. JOHN G. FOSS 592
Dissociation pressures, A dynamic method for measuring. M. R. LORENZ AND G. J. JANZ ... 611
Dissociation quotient of bromcresol green, The: A class study of ionic strength effects. RICHARD W. RAMETTE ... 252
Dissolving difficultly soluble salts with chelating ion exchange resins. RONALD RICH ... 414
Distillation, Vacuum, with an all-glass rotary evaporator. M. BENTON NAFF AND WILLIAM SPECTOR ... 327
Division of Chemical Education of ACS
Condensed norms: ACS cooperative examinations ... 115
Nominations for officers, 1963–64 ... 271
Objectives and needs, EDWARD C. FULLER *Chairman* ... 223

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Officers—1964 475
Program for New York meeting ACS Division of Chemical Education A568
Treasurer's report. WILLIAM G. KESSEL 665
Visiting scientists program in chemistry, The. ROBERT C. BRASTED 329
Documentation centers, German chemical and atomic energy. H. A. BUCH 82
Dreiding models, Plastic. LOUIS F. FIESER 452
Dreiding-type molecular models, Disc-shaped attachments for. E. C. KOOYMAN 204
Duhem and the Gibbs-Duhem equation. DONALD G. MILLER 648
Dynamic behavior of coupled systems of chemical reactions, Demonstrating the. R. M. LAGO, J. WEI, AND C. D. PRATER 395
Dynamic method for measuring dissociation pressures, A. M. R. LORENZ AND G. J. JANZ 611

Early history of carbon-14, The. MARTIN D. KAMEN 234
Early history of chemistry in Hungary, The. FERENC SZABADVÁRY (RALPH E. OESPER, *Translator*) 46
Editorially speaking 1, 53, 107, 173, 233, 283, 337, 391, 445, 503, 561, 617
Educational programs
Review—SAMA award address 460
Effect of chloride ion on precipitation of cadmium sulfide. Tested demonstration. A313
Effective teaching of organic chemistry. FRANK L. LAMBERT 173
Electrical discharges in preparative inorganic chemistry, Uses of. ALAN G. MASSEY 311
Electrochemistry
Galvanic cells experiment 363
Magnesium cell demonstration 43
Tantalum electrodes 320
Electrodes for depositions, Using tantalum and platinum-clad tantalum. EUGENE D. OLSEN, R. F. EAKIN, AND W. J. BLAEDEL 320
Electrolysis of sodium through glass. Tested demonstration A313
Electrolytes
Hydrated hydronium 637
Electronic spectra of transition metal complexes. RICHARD L. CARLIN 135
Electrophoretic study of synthetic food dyes. M. H. ANWAR, S. NORMAN, B. ANWAR, AND P. LAPLACA 537
Electrostatic view of chemical forces, A classical. H. H. JAFFÉ 649
Elementary processes, A course in kinetics based on. RICHARD M. NOYES 584
Elements, chemical, Naming in Chinese. RUFUS SUTER 44
CHANG, J. C. (L) 388
TUNG, CHEN TA (L) 388
WU, CHISUNG (L) 388
Emission Spectroscopy. Topics in Chemical instrumentation. STEPHEN E. WIBERLEY AND HERBERT H. RICHTOL A927
Enamines, The chemistry of. JOSEPH A. WEST 194
Energies, Intrinsic bond. S. SIEGEL AND B. SIEGEL 143
Energy relations in teaching organic chemistry. NORMAN L. ALLINGER 201
Enrichment program in chemistry for the advanced high school student. GEORGE L. JONES, JR. 605
Entropy data, Heat of vaporization of I_2 using absolute: A physical chemistry experiment. FRED E. STAFFORD 249
Equilibria in general chemistry, Heterogeneous. LEONARD C. GROTZ 479
Equilibrium, chemical, An experimental program on. R. N. REUSCH AND P. H. CARNELL 27
Equilibrium constant, Static and kinetic measurements of an: A physical-inorganic chemistry experiment. DOYLE BRITTON AND Z Z. HUGUS, JR. 607
Equilibrium study: A photometric formation of monothiocyanatoiron(III). RICHARD W. RAMETTE 71
Equilibrium, Temperature dependence of: A first experiment in general chemistry. BRUCE H. MAHAN 293
Erratum: Multicenter and Assisted Mechanistic Pathways (*cf.* THIS JOURNAL, 40, 185 (1963)) 326
Erratum: The Cesium Ratio (*cf.* THIS JOURNAL, *39*, 536 (1962)) 26
Error, Theoretical titration: In potentiometric, asymmetrical precipitation titrations. HOWARD L. CHRISTOPHERSON 63
Errors, Calculating titration. JAMES N. BUTLER 66
Errors in the determination of association constants, Random and systematic. R. A. PASTERNAK AND A. P. BRADY 254
Esterification for the introductory organic laboratory course: A modified Dean-Stark trap. W. H. PUTERBAUGH, C. H. VANSELOW, K. NELSON, AND E. J. SHRAWDER 349
Ether, methyl ethyl, Student preparation and manipulation of a gas. JOSEPH CASANOVA, JR. 41
Evaluating a chemistry program. RENEÉ G. FORD 16
Evaluation of the Toledo chemistry placement examination, An. NELSON W. HOVEY AND ALBERTINE KROHN 370
Evans, Joseph (P) 108
Evaporator for heat sensitive compounds, Simple. CHARLES R. BEGEMAN 427
Evaporator, Vacuum distillation with an all glass rotary. M. BENTON NAFF AND WILLIAM SPECTOR 327
Examinations
Letter 50
Objective tests 107
Exothermicities of compounds to chemical bonding, Relationship of. BERNARD SIEGEL 308
Experiment with galvanic cells, An: For the general chemistry laboratory. CLYDE R. DILLARD AND PATTY HALL KAMMEYER 363
Experimental laboratory course, An. MELVIN S. NEWMAN AND PAUL G. GASSMAN 203
Experimental program on chemical equilibrium, An. R. N. REUSCH AND P. H. CARNELL 27
Experiments in radiochemistry, Criteria for. HERBERT M. CLARK 618
Extraction of cobalt(II) complexes: A radiochemistry experiment. JOHN C. SHEPPARD AND REILLY C. JENSEN 33
Extraction, successive, of the heavier phase, Separatory funnel for. ROBERT J. HANRAHAN 69
Eye-dropper bulbs, Uses for rubber. MEYER M. MARKOWITZ AND DANIEL A. BORYTA 482

Flash of genius, The. ALFRED B. GARRETT
12. Radioactive tracers: George de Hevesy 36
13. Carbon-14 dating: Willard F. Libby 76
14. The positron: C. D. Anderson 123
15. Discovery of insulin: Frederick Banting 211
16. Quantum theory: Max Planck 262
17. Discovery of the transistor: W. Shockley, J. Bardeen, and W. Brattain 302
Flowing clock reactions. M. L. HAGGETT, PETER JONES, AND K. B. OLDHAM 367
Fluidized-solid constant temperature bath, A small. HARRY E. WEIR AND T. F. RUTLEDGE 425
Foam fractionation, Separation of surface active compounds by. R. M. SKOMOROSKI 470
Fog formation. Tested demonstration A477
Food dyes, Electrophoretic study of synthetic. M. H. ANWAR, S. NORMAN, B. ANWAR AND P. LAPLACA 537
Forces, A classical electrostatic view of chemical. H. H. JAFFÉ 649
Formaldehyde clock reaction, The theory of the. PETER JONES AND K. B. OLDHAM. 366
Formation constants of a metal-anionic ligand system in dioxane-water. DAVID E. GOLDBERG 341
Formation of monothiocyanatoiron(III): A photometric equilibrium study. RICHARD W. RAMETTE 71
Freezing point observations on micellar solutions. ERIC HUTCHINSON AND FUMIKATSU TOKIWA 472
Freshman chemistry, Technical report writing in. NELSON MCKAIG, JR. 86
Freshman laboratory, Instrument for the: Magnetic stirrer. W. H. SLABAUGH 642
Friedel-Crafts alkylation. Textbook errors, 44. KENNETH L. MARSI AND SAMUEL H. WILEN 214
Fuller, E. C. (P) 223
Funnel, Separatory, for successive extraction of the heavier phase. ROBERT J. HANRAHAN 69

Galvanic cells, An experiment with: For the general chemistry laboratory. CLYDE R. DILLARD AND PATTY KAMMEYER 363
Galvanism?, Who discovered. EDWARD F. KOHMAN 655
Gas, A simple condensation isotherm for a hard sphere. FRED VASLOW 485
Gas chromatography demonstration apparatus, A. JOHN MCLEAN AND PETER L. PAUSON 539
Gas chromatography, Determining activity coefficients by: A physical chemistry experiment. SUSAN KENWORTHY, JAMES MILLER, AND D. E. MARTIRE 541
Gas chromatography, Terminology of A170
Gas—methyl ethyl ether, Student preparation and manipulation of a. JOSEPH CASANOVA, JR. 41
Gas saturation apparatus, A. PAUL SCHATZBERG 267
Gaseous species at high temperatures, Stable. BERNARD SIEGEL 304
Gases, The chemical behavior of ions in. J. L. FRANKLIN 284
Gelatin, Demonstrating the Weissenberg effect with. JAMES H. WIEGAND 475
General chemistry
Electrochemistry demonstration 43
Equilibrium experiment 293
Galvanic cell experiment 363
Kinetics symposium 573
Stereochemistry introduction 438
Teaching equilibria 479
General chemistry laboratory, A simple kinetics experiment for. W. H. CONE AND R. A. HERMENS 421
General chemistry, Placement in. VIRGINIA M. SCHELAR, ROBERT B. CLUFF, AND BERNICE ROTH 369
Genetically related radionuclides: Growth-decay studies of ThB-ThC. P. P. PAREKH AND M. SANKAR DAS 354
Geochemistry, Modern. W. S. FYFE 330
German chemical and atomic energy documentation centers. H. A. BUCH 82
Gibbs-Duhem equation
Letters in regard to (THIS JOURNAL, **39**, 527 (1962)) 225-8
Gibbs-Duhem equation, Duhem and the. DONALD G. MILLER 648
Gilmont, Roger (P) A491
Glass electrode *p*H meter using a vacuum tube voltmeter, A. HAROLD E. BROWER 85
Glass, Recent developments in. ROBERT H. DALTON 99
Glossary, Chromatographic. Topics in chemical instrumentation. S. Z. LEWIN, *Editor* A167
Gordon, Saul (P) A87
Grades, Adjusting quiz, to a common scale. LOWELL W. BAHE 90

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Graduate placement test in analytical chemistry. Condensed norms: ACS cooperative examinations 115
Graduate placement test in organic chemistry. Condensed norms: ACS cooperative examinations 115
Graphical treatment simplifies acid-base equilibria calculations. E. B. THOMAS. 70
Graphite, The physical and chemical character of. PETER A. H. TEE AND BRIAN L. TONGE 117
Grids for ternary systems, Conversion. E. L. HERIC 325
Growth-decay studies of ThB-ThC: Genetically related radionuclides. P. P. PAREKH AND M. SANKAR DAS 354

Haenisch, Edward L. (P) ..... Sept. cover
Halides, Ionic and molecular, of the phosphorus family. ROBERT R. HOLMES ... 125
Harmonic oscillator and rigid rotator, An approximate wave mechanical treatment of the. RONALD RICH 365
Hassid, W. Z. (P) 239
HCl, Vibration-rotation spectrum of: A physical chemistry experiment. F. E. STAFFORD, C. W. HOLT, AND G. L. PAULSON 245
Heat of vaporization of I_2 using absolute entropy data: A physical chemistry experiment. FRED E. STAFFORD 249
Heterogeneous equilibria in general chemistry. LEONARD C. GROTZ 479
Hevesy, George de: Radioactive tracers. The flash of genius, 12. ALFRED B. GARRETT 36
High capacity vapor traps. JAMES R. KUPPERS 242
High pressure techniques for microscale reactions. RICHARD P. RHODES 423
High school chemistry
CBA and CHEMS 337
Enrichment program 605
$KClO_3$ decomposition 94
High school chemistry, Programed instruction in. VIRGINIA P. POWELL 23
High school student, advanced, An enrichment program in chemistry for the. GEORGE L. JONES, JR. 605
High schools, Organic chemistry in Ohio. ETHELREDA LAUGHLIN 209
High temperatures, Stable gaseous species at. BERNARD SIEGEL 304
Hirshberg, Y.—In memoriam. E. FISCHER 112
History of chemistry
Carbon-14 dating 76
Carbon-14 discovery 234
Chugaev, Lev Aleksandrovich 656
Concepts of time 574
Duhem and the Gibbs-Duhem Equation. 648
Early Hungary 46
Galvanism 655
Glass 99
Insulin 211
Positron 123
Prout's Bridgewater Treatise 652
Radioactive tracers 36
Ruprecht, Antole 47
Russia 108
Stellar spectroscopy 612
Humic acid, What is? CORNELIUS STEELINK 379
Hungary, The early history of chemistry in. FERENC SZABADVÁRY (RALPH E. OESPER, *Translator*) 46
Hydrated hydronium ion. The. H. LAWRENCE CLEVER 637
Hydrogen bonds, On: Textbook errors, 47. JERRY DONOHUE 598
Hydronium ion, The hydrated. H. LAWRENCE CLEVER 637

Ideal gas pressure, Rigorous derivation of the kinetic equation for. M. W. C. DHARMAWARDHANA AND K. G. A. DHARMAWARDANE 318
Ihde, Aaron J. (P) 105
Improved synthesis of 2-bromonaphthalene, An. F. A. VINGIELLO, T. J. DELIA, P. POLSS, and D. FARRIER 544
Industrial chemistry
Graphite uses 117
Inexpensive spectrograph of moderately high resolution, An. RALPH SCHOENBECK AND FREDERICK D. TABBUTT 452
Information-transmitting molecule, Ribonucleoc acid, the simplest. H. FRAENKEL-CONRAT 216
Ink pigments, TLC separation of. LEONARD F. DRUDING 536
Inorganic chemistry
Alkali metal-water reactions 633
Arsenate iodide kinetics 607
Benzene clathrate 646
Bond energies 143
Bonding and thermodynamic properties. 308
n-Center bonds 385
Clathrates 643
Close packing models 61
Diphosphorus compounds 153
Experiment on complexes 476
Formaldehyde clock 366
Formation constants experiment 341
Gases at high temperatures 304
Glass developments 99
Hydrogen selenide stability 149
Inert gas compounds 277
Ionic crystal structures 54
$KClO_3$ decomposition ..... 78, (L)94, (L)94
Kinetics course 587
Mineralogy 512
Neptunium chemistry 35
Non-existent compounds ..... 130, (L)270
Organometallics 159
Phosphorus halides 125
Praesodymium oxides 150
Preparations of phosphors ..... 362, (L)667
Rare earth experiments 433
Reaction in electrical discharge 311
Spectra of complexes 135
Stoichiometry experiments 344
VSEPR theory 295
Inorganic nutrients in the sea. JOHN W. VANLANDINGHAM 272
Inorganic reaction mechanisms by volumetric analysis: Oxidation of iodide ion. G. J. MOODY AND J. D. R. THOMAS ... 151
Inorganic superoxides, The. A. W. PETROCELLI AND D. L. KRAUS 146
Instruction, programed: Symposium 11
Instrument for the freshman laboratory: Magnetic stirrer. W. H. SLABAUGH ... 642
Instrumentation, A modular approach to chemical. EDWARD N. WISE 73
Instrumentation for particle size analysis. Topics in chemical instrumentation. S. Z. LEWIN.
Part 1 ..... A257
Part 2 ..... A349
Part 3 ..... A423
Insulin, Discovery of: Frederick Banting. The flash of genius, 15. ALFRED B. GARRETT 211
Intrinsic bond energies. S. SIEGEL AND B. SIEGEL 143
Intrinsic programs. JESSE H. DAY 14
Inverted mirror image, An. SCOTT L. KITTSLEY 558
Iodide ion as a qualitative reagent: Detection of nitrite and sulfite. ARMINE D. PAUL AND JOHN A. GIBSON, JR. 417
I_2 using absolute entropy data, Heat of vaporization of: A physical chemistry experiment. FRED E. STAFFORD 249
Ion combination reactions, Potentiometric titration curves for simple. JAMES A. GOLDMAN 519
Ion exchange method, Removal of hardness and deionization of water by the. Tested demonstration A987
Ion exchange resins, Dissolving difficulty soluble salts with chelating. RONALD RICH 414
Ionic and molecular halides of the phosphors family. ROBERT R. HOLMES ... 125
Ionic crystal structures, Standard. WILLIAM G. GEHMAN 54
Ionic strength effects, A class study of: The dissociation quotient of bromcresol green. RICHARD W. RAMETTE 252
Ions, aqueous, and other chemical species, Conventions defining thermodynamic properties of. RICHARD M. NOYES 2
Ions in gases, The chemical behavior of. J. L. FRANKLIN 284
Ireland, Scientific education in. J. A. SHUFLE 88
Iron tricarbonyl complexes, Chemistry of diene-. R. PETTIT, G. EMERSON, AND J. MAHLER 175
Isoelectric point of a protein, Viscometric determination of the. JOHN E. BENSON 468
Isomerism in aliphatic chains, Models illustrating rotational. H. J. G. HAYMAN 208
Isomorphism
Minerals and chemistry 512
Isotherm for a hard sphere gas, A simple condensation. FRED VASLOW 485
Isotopes, Hydrogen. Tested overhead projection series. HUBERT N. ALYEA .. A460

Jordan, Joseph (P) A5

Kamen, Martin D. (P) ....234, 238, May cover
Kinetics
Arsenate iodide 607
Coupled systems demonstrations 395
Order evaluation 269
Kinetic equation for ideal gas pressure, Rigorous derivation of the. M. W. C. DHARMANWARDHANA AND K. G. A. DHARMAWARDANE 318
Kinetic measurements of an equilibrium constant, Static and: A physical-inorganic chemistry experiment. DOYLE BRITTON AND Z Z. HUGUS, JR. 607
Kinetic studies below room temperature, A reaction vessel for. G. C. LALOR ... 597
Kinetic theory description of transport phenomena, A unified. ELDON KNUTH 486
Kinetics, A laboratory program in chemical. JAMES E. FINHOLT 589
Kinetics based on elementary processes, A course in. RICHARD M. NOYES 584
Kinetics— early and often. J. A. CAMPBELL 578
Kinetics experiment for general chemistry laboratory, A simple. W. H. CONE AND R. A. HERMENS 421
Kinetics experiment for the physical chemistry laboratory. A. ROBERT D. WHITAKER 264
Kinetics for the undergraduate: Symposium. EDWARD L. KING 573
Kinetics in laboratory and classroom, Chemical. ROBERT E. CONNICK 587
Kinetics in the study of organic reaction mechanisms. ROBERT H. DEWOLFE .. 95
SONG, PILL-SOON (L) 555
Kinetics, Polymerization, and viscometric characterization of polystyrene: A physical chemistry experiment. J. H. BRADBURY 465
Kjeldahl apparatus, A "direct attachment." J. STOCK AND A. V. DETHOMAS 87

Laboratory course, An experimental. MELVIN S. NEWMAN AND PAUL G. GASSMAN 203
Laboratory cylinder-mill for small samples. M. D. SCHLESINGER, S. NAZARUK, AND LESLIE REGGEL 546
Laboratory experiments
Activity coefficients by VPC 541
Alkali metal-water reactions 633

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Analytical of inorganic mehanism 151
Analytical organic 93
Arsenate iodide kinetics 607
Blue bottle kinetics 573
2-Bromonaphthalene synthesis 544
Calculations for I_2 from spectra 249
Carbon-14 in organic chemistry 206
Cobalt(II) complexes by radioisotopes ... 33
Criteria for radiochemistry 618
Diels-Alder reaction 40, 543
2,4-Dinitroaniline synthesis 545
Diphenylamine synthesis 346
Dissociation pressures 611
Electrophoresis 537
Equilibrium study 71
Esterification 349
Foam fractionation experiment 470
Formation constants 341
Freezing point of micellar solutions 472
Galvanic cells 363
HCl spectrum 245
Inorganic complexes 476
Ion combinations by potentiometry 519
Isopropyl ether hazard 469
K_{diss} from bromcresol green 252
$KClO_3$ decomposition ..... 78, (L)94, (L)94
Kinetics at Berkeley 587
Kinetics of complex ion dissociation 264
Kinetics program 589
Lasers for physical chemistry 338
Measuring water activity 419
Methyl ethyl ether synthesis 41
Neptunium chemistry 35
NMR spectra 358
Organic 203
Organic analysis 93
Organic synthesis 174
Oxidation of mercaptans 39
Pinene organics 347
Plant pigments by thin layer chromatography 29
Polaroid camera for radioautography 243
Polymers 465
Preparations of phosphors ..... 362, (L)667
Protein isoelectric point 468
Quantitative paper chromatography 408
Radiochemistry growth-decay 354
Rare earths 433
Semimicro Rast method 422
Simple kinetics 421
Spectrograph 452
Stereochemistry of (−) menthol 205
Stoichiometry 344
Thallium(I) bromide solubility by radioisotopes 34
Thermodynamics for general chemistry .. 293
Thin layer chromatography 531, 534, 536
Tl(I)Br solubility by radioisotopes 34
Laboratory program in chemical kinetics, A. James E. Finholt 589
Lantern slides, The preparation of inexpensive. William H. R. Shaw and John N. Aronson 483
Rubin Battino (L) 667
Lanthanides, The lighter: A laboratory experiment in rare earth chemistry. George B. Kauffman, Lloyd T. Takahashi, and R. C. Vickery 433
Laser experiments in undergraduate physical chemistry laboratory. Richard G. Layton and Edward M. Eyring .. 338
Lead, Dating of uranium minerals by the specific radioactivity of. A. W. Fairhall 626
Leaf pigments, Thin layer chromatographic separation of: A rapid demonstration. Charles Rollins 32
Lecture demonstrations
Alkali metal-water reactions 633
Blue bottle kinetics 578
Clock reaction theory 366
Coupled systems 395
Electrophoresis of food dyes 537
Flowing clock reactions 367
Gas chromatography 539
Inexpensive slides ..... 483, (L)667
Magnesium cell 43
Maxwell's demon demonstrator 49
Thin layer chromatography 531, 534, 536
Weissenberg effect 475
Leicester, Henry M. (P) ..... 108, March cover
Libby, Willard F.: Carbon 14-dating. The flash of genius, 13. Alfred B. Garret 76
Liberal arts colleges
Research publications ..... (L)228
Ligand system in dioxane-water, Formation constants of a metal-anionic. David E. Goldberg 341
Lighter lanthanides, The: A laboratory experiment in rare earth chemistry. George B. Kauffman, Lloyd T. Takahashi, and R. C. Vickery 433
Liquids, Significant structure theory of. Henry Eyring and R. P. Marchi 562
Low temperature zone refining apparatus. Morris Zief, Hollister Ruch, and Charles H. Schramm 351
Luminescent compounds, i.e., phosphors. Tested demonstrations A49

Magnesium cell for demonstration. Prem Behari Mathur and Nityanandan J. Paul 43
Magnetic stirrer: Instrument for the freshman laboratory. W. H. Slabaugh 642
Manometer, A simple closed end. Elmer R. Trumbull 350
Mass spectrometry
Ions in gases 284
Maxwell's demon demonstrator. M. V. Sussman 49
Measurement, Micrometric methods of volume. Topics in chemical instrumentation. Roger Gilmont A491
Measuring temperature in a closed rotating flask, Device for. Eugene K. Lubbs .. 200
Mechanisms, Inorganic reaction, by volumetric analysis: Oxidation of iodide ion. G. J. Moody and J. D. R. Thomas 151
Mechanisms, Kinetics in the study of organic reaction. Robert H. De Wolfe 95
Song, Pill-Soon (L) 555
Mechanisms, 2. Reactions and: Cyclobutane chemistry. Armin Wilson and David Goldhamer 599
Mechanistic pathways in the reactions of organometallic compounds, Multicenter and assisted. Raymond E. Dessy and Frank Paulik ..... 185, (E)326
Mendeleev have predicted the existence of XeF_4?, Would. Roland Ward 277
Menthol, The stereochemistry of (−): An organic laboratory experiment. Harmon C. Dunathan 205
Mercaptans to disulfides, A convenient synthetic technique to oxidize. T. J. Wallace, W. Bartok, and A. Schrieshiem 39
Metal-anionic ligand system in dioxane-water, Formation constants of a. David E. Goldberg 341
Method for determining order of a reaction. Howard K. Zimmerman 356
Methyl ethyl ether, Student preparation and manipulation of a Gas. Joseph Casanova, Jr. 41
Micellar solutions, Freezing point observations on. Eric Hutchinson and Fumikatsu Tokiwa 472
Micrometric methods of volume measurement, Topics in chemical instrumentation. Roger Gilmont A491
Microscale reactions, High pressure techniques for. Richard P. Rhodes 423
Microscope slides, TLC on: An organic chemistry experiment. M. Benton Naff and Anna S. Naff 534
Miller, William Allen (P) 612
Miller, William Allen: Pioneer stellar spectroscopist. Fred Trusell 612
Minerals, and chemistry, Crystals. Duncan McConnell and Frank H. Verhoek 512
Minerals by the specific radioactivity of lead, Dating of uranium. A. W. Fairhall 626
Mirror image, An inverted. Scott L. Kittsley 558
Mnemonics for thermodynamic equations. Edward T. Radley, Irwin Cohen, and Brother Thomas McCullough, CSC 261
Models
Atomic and molecular orbitals 256
Close packing 61
Conformational effects 28
Crystal forms 54
Modified Dreiding 204
Plastic Dreiding 457
Rotational isomerism 208
Tangent-sphere 446, 523
Models illustrating rotational isomerism in aliphatic chains. H. J. G. Hayman ... 208
Modern geochemistry. W. S. Fyfe 330
Modification of a vacuum desiccator. E. L. Head and D. Pavone 316
Modified Victor Meyer apparatus. G. Wilson Drake 606
Modular approach to chemical instrumentation, A. Edward N. Wise 73
Molecular distillation and vacuum sublimation, Apparatus for. Bernard Loev, Kenneth M. Snader, and Minerva F. Kormendy 426
Molecular models, Disc-shaped attachments for Dreiding-type. E. C. Kooyman ... 204
Molecular orbital structures, Rules for. Herbert Meislich 401
Molecular orbitals, Contour surfaces for atomic and. E. A. Ogryzlo and Gerald B. Porter 256
Molecular weights, Semimicro modification of the Rast method for determining. E. J. Cowles and M. T. Pike 422
Monoclinic sulfur crystals. Tested demonstration A477
Monothiocyanatoiron(III), Formation of: A photometric equilibrium study. Richard W. Ramette 71
More wealth from agriculture. William P. Ratchford and Norman E. Roberts 556
Moscow State University, Chemistry at. Richard E. Bozak 376
Multicenter and assisted mechanistic pathways in the reactions of organometallic compounds. Raymond E. Dessy and Frank Paulik ..... 185, (E)326

Naming chemical elements in Chinese. Rufus Suter 44
Chang, J. C. (L) 338
Tung, Chen Ta (L) 388
Wu, Chisung (L) 388
National Bureau of Standards values for physical constants 642
Neptunium, Some chemical properties of: A radiochemistry experiment. John C. Sheppard and Reilly C. Jensen .. 35
New England Association of Chemistry Teachers:
Articles
Maxwell's demon demonstrator. M. V. Sussman 49
More wealth from agriculture. William P. Ratchford and Norman E. Roberts 556
Recent developments in glass. Robert H. Dalton 99
Stereochemistry in the terminal course. Gordon G. Evans 438
Use of *n*-center bonds, The. Gene B. Carpenter 385
Would Mendeleev have predicted the existence of XeF_4? Ronald Ward. 277
NEACT twenty-fifth summer conference 279
Officers for 1963-64 440
Official business. Robert D. Eddy 666
Nitrite and sulfite, Iodide ion as a qualitative reagent: Detection of. Armine D. Paul and John A. Gibson, Jr. 417

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Nitrous acid, The reaction of tertiary amines with. George E. Hein 181
NMR spectra, A qualitative approach to the study of complex. Donald E. McGreer and M. M. Mocek 358
Non-cyanide detection of cadmium. R. L. Dutta and S. Dutta Choudhury 414
Non-existent Compounds. W. E. Dasent. Schleyer, Paul von R (L) 130, 270
Notes on qualitative analysis. A Chem Ed collection 413
Nuclear chemistry
Carbon-14 dating 76
Nuclear science, Sponsorship of committee on—NAS-NRC. N. E. Ballou 618
Nucleic acids
RNA—information carrier 216
Nutrients in the sea, Inorganic. John W. VanLandingham 272

Objectives and needs of the Division of Chemical Education. Edward C. Fuller, *Chairman* 223
Olson, C. L. (P) A549
On hydrogen bonds: Textbook errors, 47. Jerry Donohue 598
Orbitals, Contour surfaces for atomic and molecular. E. A. Ogryzlo and Gerald B. Porter 256
Order of a reaction, Method of determining. Howard K. Zimmerman 356
Organic chemistry
Benzene clathrate 646
2-Bromanaphthalene synthesis 544
Bromonium ion 392
Carbon-14 experiments 206
Clathrates 643
Contributions of Lev Aleksandrovich Chugaev 656
Cyclobutane 504, 599
Decarboxylation of acids 213
Diels-Alder reaction 40, 543
Diene complexes 175
2,4-Dinitroaniline synthesis 545
Enamines 194
Energy relationships 201
Experimental laboratory 203
Friedel-Crafts alkylation 214
Humic acid 379
Iodination of aniline 270
Isopropyl ether hazard 469
Kinetics and mechanisms ..... 95, (L)555
Mechanism of Friedel-Crafts 214
Methyl ethyl ether experiment 41
Models for rotational isomerism 208
Molecular orbital rules 401
Multicenter mechanisms ..... 185, (E)326
Oxidation of mercaptans 39
Plastic Dreiding models 62, 457
Ribonucleic acid 216
Stereochemistry of (−) menthol 205
Tangent-sphere models 446, 523
Tetiary amines—nitrous acid 181
Organic chemistry, Effective teaching of. Frank L. Lambert 173
Organic chemistry, Energy relations in teaching. Norman L. Allinger 201
Organic chemistry experiment, An: TLC on microscope slides. M. Benton Naff and Anna S. Naff 534
Organic chemistry in Ohio high schools. Ethelreda Laughlin 209
Organic experiment with carbon-14, An undergraduate. John C. Wright 206
Organic experiments, α-Pinene, a starting material for a sequence of. X. A. Domínguez and G. Leal 347
Organic laboratory courses, Project syntheses for. Stanley C. Bunce 174
Organic reaction mechanisms, Kinetics in the study of. Robert H. DeWolfe 95
Song, Pill-Soon (L) 555
Organic semiconductors. Norman J. Juster 547
Organometallic compounds, Multicenter and assisted mechanistic pathways in the reactions of. Raymond E. Dessy Frank Paulik ..... 185, (E)326
Organometallic derivatives of the transition elements. Herbert D. Kaesz 159
Overhead projection series, Tested: TOPS in general chemistry. Hubert N. Alyea A29, A131, A213, A303, A383, A459, A523, A575, A635, A813, A885, A947
Overhead projector, An inexpensive. TOPS Hubert N. Alyea A523
Oxidation of bromide and iodide ions. Tested demonstrations A241
Oxidation of iodine. Tested demonstration. A593
Oxidize mercaptans to disulfides, A convenient synthetic technique to. T. J. Wallace, W. Bartok, and A. Schrieshiem 39
Oxygen in air. Tested demonstration A477

Packing, close, Some models of. Rodney J. Sime 61
Paper chromatography, A quantitative experiment with. W. Joe Frierson, Nina Marable, and Becky Bruce 408
Papers, The professional presentation of scientific. Harold G. Cassidy 373
Paramagnetism. Tested demonstration A409
Particle size analysis, Instrumentation for. Topics in chemical instrumentation. S. Z. Lewin. Part 1 ..... A257
Part 2 ..... A349
Part 3 ..... A423
Peroxide, isopropyl ether, A sobering experience with. Irwin B. Douglass 469
*p*H meter, A glass electrode, using a vacuum tube voltmeter. Harold E. Brower 85
Phase diagrams, A unified interpretation of two-component phase diagrams. George L. Jones, Jr. 38
Philosophy of science
Editorially speaking 445
Phosphors, Luminescent compounds, i.e. Tested demonstrations A49
Phosphors, Simple preparations of. F. F. Mikus 362
De Ment, Jack (L) 667
Phosphorus family, Ionic and molecular halides of the. Robert R. Holmes 125
Photometric equilibrium study, A: Formation of monothiocyanatoiron(III). Richard W. Ramette 71
Physical and chemical character of graphite, The. Peter A. H. Tee and Brian L. Tonge 117
Physical chemistry
Absorption, dispersion, circular dichroism, and rotary dispersion 592
Arsenate iodide kinetics 607
Conduction and semiconduction 489
Electrostatic chemical forces 649
Errors in association constants 254
Formation constants experiment 341
Hirshberg's contribution to photochemistry 112
Hydrated hydronium 637
Ionic strength experiment 327
Kinetic theory 318, 486
Kinetics symposium 573
Mass spectrometry 284
Orbital contour surfaces 256
Order of reaction 356
Organic semiconductors 547
Phase diagrams 38
Polymer experiment 465
Raoult's law 516
Ternary systems calculations 325
Theory of liquids 562
Vapor density experiment 323
Vapor pressure calculations 317
Zero point energy calculations 93
Physical chemistry experiment, A: Determining activity coefficients by gas chromatography. Susan Kenworthy, James Miller, and D. E. Martire 541
Physical chemistry experiment, A: Heat of vaporization of I_2 using absolute entropy data. Fred E. Stafford 249
Physical chemistry experiment, A: Vibration-rotation spectrum of HCl. F. E. Stafford, C. W. Holt, and G. L. Paulson 245
Physical chemistry laboratory, A kinetics experiment for the. Robert D. Whitaker 264
Physical chemistry laboratory, Laser experiments in undergraduate. Richard G. Layton and Edward M. Eyring 338
Physical constants, National Bureau of Standards values for 642
Physical properties of hydrogen. Tested overhead projection series. Hubert N. Alyea A459
Pietsch, E. H. E. (P) 83
α-Pinene, a starting material for a sequence of organic experiments. X. A. Domínguez and G. Leal 347
Placement examination, An evaluation of the Toledo chemistry. Nelson W. Hovey and Albertine Krohn 370
Placement in general chemistry. Virginia M. Schelar, Robert B. Cluff, and Bernice Roth 369
Planck, Max: Quantum theory. The flash of genius, 16. Alfred B. Garrett 262
Plant pigments, Separation of, by thin layer chromatography. M. H. Anwar 29
Plastic Dreiding models. Louis F. Fieser 457
Platinum-clad tantalum electrodes for depositions, Using tantalum and. Eugene D. Olsen, R. F. Eakin, and W. J. Blaedel 320
Platinum, Terpenes to: The chemical career of Lev Aleksandrovich Chugaev. George B. Kauffman 656
Polaroid camera, Demonstration of radioautography and paper chromatography using a. Jack C. Towne and Bonnie M. Gatti 243
Polymer chemistry
Experiment 465
Foam fractionation experiment 470
Isoelectric experiment 468
Polymerization kinetics and viscometric characterization of polystyrene: A physical chemistry experiment. J. H. Bradbury 465
Polystyrene, Polymerization kinetics and viscometric characterization of: A physical chemistry experiment. J. H. Bradbury 465
Positron, The: C. D. Anderson. The flash of genius, 14. Alfred B. Garrett 123
Potassium chlorate, The catalyzed decomposition of. James M. Gaidis (*Contributed by* Eugene G. Rochow) 78
E. Gerald Meyer and Elbert C. Weaver (L) 94
Bernard Jurale (L) 94
Potentiometric titration curves for simple ion combination reactions. James A. Goldman 53
Power supply, Constant current. Harry J. Svec and Norman C. Peterson 19, 37
Praesodymium Oxide-Oxygen Generator. Paul A. Faeth and A. F. Clifford 150
Precipitation of cadmium sulfide, Effect of chloride ion on. Tested demonstration A313
Preparation and analysis of a complex compound. Donald K. Sebera 476
Preparation of diphenylmethane: Simplified procedure: purer product. William D. Ellis 346
Preparation of inexpensive lantern slides, The. William H. R. Shaw and John N. Aronson 483
Rubin Battino (L) 667
Preparation of solutions for qualitative analysis with a cation exchange resin. Paul Key, Edward Sohl, Robert Tiews, and Clark Bricker 416
Preparative inorganic chemistry, Uses of electrical discharges in. Alan G. Massey 311

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Present and future of qualitative analysis, The: Report of a survey. NELSON W. HOVEY 410
Pressure measurement. Topics in chemical instrumentation. SEYMOUR T. ZENCHELSKY Part 1 ..... A611
Part 2 ..... A771
Part 3 ..... A849
Pressure stopcock, A simple. ROGER GILMONT 432
Pressures, A dynamic method for measuring dissociation. M. R. LORENZ AND F. J. JANZ 611
Professional ethics
Editorially speaking 233
Professional presentation of scientific papers, The. HAROLD G. CASSIDY 373
Program for New York meeting ACS Division of Chemical Education A568
Programed instruction: Symposium 11
Programed instruction in high school chemistry. VIRGINIA P. POWELL 23
Programed instruction in qualitative analysis laboratory. IRWIN COHEN AND ROBERT FETTEROLF 25
Programing as an aid to effective chemistry teaching. G. R. BAKKER, O. T. BENFEY, AND W. J. STRATTON 18
Programs, Intrinsic. JESSE H. DAY 14
Progress, A decade of unusual. EDWARD L. HAENISCH 460
Project syntheses for organic chemistry laboratory courses. STANLEY C. BUNCE 174
Projector, An inexpensive overhead. TOPS HUBERT N. ALYEA A523
Proposals for significant research in chemistry. AMOS G. HORNEY 110
Protective device, Beam, for an automatic analytical balance. ROBERT VOLLMER 77
Protein, Viscometric determination of the isoelectric point of a. JOHN E. BENSON 468
Prout's chemical Bridgewater Treatise. W. H. BROCK 652
Publications, chemical, in liberal arts colleges 228

Qualitative analysis
Collection of notes 413
Qualitative analysis laboratory, Programed instruction in. IRWIN COHEN AND ROBERT FETTEROLF 25
Qualitative analysis, The present and future of: Report of a survey. NELSON W. HOVEY 410
Qualitative approach to the study of complex NMR spectra, A. DONALD E. MCGREER AND M. M. MOCEK 358
Qualitative detection of Ba, Sr, and Ca ions. RICHARD PARIZA 417
Quantitative analysis course, Weight burets for the. SHIRLEY WALTER GADDIS 324
Quantitative experiment with paper chromatography, A. W. JOE FRIERSON, NINA MARABLE, AND BECKY BRUCE 408
Quantum mechanics
Atomic and molecular orbitals 256
Quantum theory: Max Planck. The flash of genius, 16. ALFRED B. GARRETT 262
Questionnaires
Editorially speaking 391
Quiz grades, Adjusting, to a common scale. LOWELL W. BAHE 90

Radioactive tracers: George de Hevesy. The flash of genius, 12. ALFRED B. GARRETT 36
Radioautography and paper chromatography using a Polaroid camera, Demonstration of. JACK C. TOWNE AND BONNIE M. GATTI 243
Radiochemistry
Carbon-14 discovery 234
Committee on nuclear science. NAS-NRC 618
Criteria for experiments 618
Dating uranium minerals 626
Licensed and exempt radionuclides 618
Separation of Th^{234} 626
ThB-ThC 354
Tl-208 separation 328
Radiochemistry, Criteria for experiments in. HERBERT M. CLARK 618
Radiochemistry experiment, A: Extraction of cobalt(II) complexes. JOHN C. SHEPPARD AND REILLY C. JENSEN 33
Radiochemistry experiment, A: Some chemical properties of neptunium. JOHN C. SHEPPARD AND REILLY C. JENSEN 35
Radiochemistry experiment, A: The solubility of thallium(I) bromide. JOHN C. SHEPPARD AND REILLY C. JENSEN 34
Random and systematic errors in the determination of association constants. R. A. PASTERNAK AND A. P. BRADY 254
Raoult's law, Deviations from. Textbook errors, 46. M. L. MCGLASHAN 516
Rare earth chemistry, A laboratory experiment in: The lighter lanthanides. GEORGE B. KAUFFMAN, LLOYD T. TAKAHASHI, AND R. C. VICKERY 433
Rast method for determining molecular weights, Semimicro modification of the. E. J. COWLES AND M. T. PIKE 422
Reaction mechanisms, Inorganic, by volumetric analysis: Oxidation of iodide ion. G. J. MOODY AND J. D. R. THOMAS 151
Reaction of tertiary amines with nitrous acid, The. GEORGE E. HEIN 181
Reaction tube for sodium and chlorine. Tested demonstrations A49
Reaction vessel for kinetic studies below room temperature, A. G. C. LALOR 597
Reactions and mechanisms, 2: Cyclobutane chemistry. ARMIN WILSON AND DAVID GOLDHAMER 599
Recent developments in glass. ROBERT H. DALTON 99
Relationship of exothermicities of compounds to chemical bonding. BERNARD SIEGEL 308
Removal of hardness and deionization of water by the ion exchange method. Tested demonstration A987
Report from the Division of Chemical Education Examinations Committee. T. A. ASHFORD 114
Report, Technical, writing in freshman chemistry. NELSON MCKAIG, JR. 86
Research in chemistry, Proposals for significant. AMOS G. HORNEY 110
Resolution, An inexpensive spectrograph of moderately high. RALPH SCHOENBECK AND FREDERICK D. TABBUTT 452
Ribonucleic acid, the simplest information-transmitting molecule. H. FRAENKEL-CONRAT 216
Richtol, Herbert H. (P) A927
Rigid rotator, An approximate wave mechanical treatment of the harmonic oscillator and. RONALD RICH 365
Rigorous derivation of the kinetic equation for ideal gas pressure. M. W. C. DHARMAWARDHANA AND K. G. A. DHARMAWARDANE 318
Rotary dispersion, Absorption, dispersion, circular dichroism, and. JOHN G. FOSS 592
Rotary evaporator. Vacuum distillation with an all glass. M. BENTON NAFF AND WILLIAM SPECTOR 327
Rotating flask, Device for measuring temperature in a closed. EUGENE K. LUBBS 200
Rotational isomerism in aliphatic chains, Models illustrating. H. J. G. HAYMAN 208
Ruben, S. (P) 239
Rules for molecular orbital structures. HERBERT MEISLICH 401
Russia, Some aspects of the history of chemistry in. HENRY M. LEICESTER 108
Russian technical information, Using. J. G. TOLPIN 430

Safety
Isopropyl ether hazard 469
Stirring bar hazard 92
Saturation, gas, apparatus, A. PAUL SCHATZBERG 267
Scientific education in Ireland. J. A. SCHUFLE 88
Scientific papers, The professional presentation of. HAROLD G. CASSIDY 373
Sea, Inorganic nutrients in the. JOHN W. VAN LANDINGHAM 272
Second law, A simple approach to the. W. G. BRECK 353
Semiconduction, Conduction and. NORMAN J. JUSTER 489
Semiconductors, Organic. NORMAN J. JUSTER 547
Semimicro modification of the Rast method for determining molecular weights. E. J. COWLES AND M. T. PIKE 422
Separation and identification of copper in the presence of cadmium. ALCÍDIO ABRÃO 413
Separation of plant pigments by thin layer chromatography. M. H. ANWAR 29
Separation of surface active compounds by foam fractionation. R. M. SKOMOROSKI 470
Separatory funnel for successive extraction of the heavier phase. ROBERT J. HANRAHAN 69
Shadowgraphs, Vapor. Tested demonstration A987
Shockley, W., Bardeen, J., and Brattain, W.: The discovery of the transistor. The flash of genius, 17. ALFRED B. GARRETT 302
Significant structure theory of liquids. HENRY EYRING AND R. P. MARCHI 562
Simple approach to the second law, A. W. G. BRECK 353
Simple closed end manometer. ELMER R. TRUMBULL 350
Simple condensation isotherm for a hard sphere gas, A. FRED VASLOW 485
Simple evaporator for heat sensitive compounds. CHARLES R. BEGEMAN 427
Simple kinetics experiment for general chemistry laboratory, A. W. H. CONE AND R. A. HERMENS 421
Simple method for the preparation of 2,4-dinitroaniline. A. A. ASHTON 545
Simple model to illustrate conformational effects in acyclic molecules, A. A. TYE AND J. B. LAPIDUS 28
Simple preparations of phorphors. F. F. MIKUS 362
DE MENT, JACK (L) 667
Simple pressure stopcock, A. ROGER GILMONT 432
Simple separation of the group II-A sulfides. A. T. A. O'DONNELL 415
Simple thermoregulator, A. SAM KATZ 266
Slides, The preparation of inexpensive lantern. WILLIAM H. R. SHAW AND JOHN N. ARONSON 483
RUBIN BATTINO (L) 667
Small fluidized-solid constant temperature bath, A. HARRY E. WEIR AND T. P. RUTLEDGE 425
Sobering experience with isopropyl ether peroxide, A. IRWIN B. DOUGLASS 469
Sodium through glass, Electrolysis of. Tested demonstration A313
Solid state
Conduction and semiconduction 489
Organic semiconductors 547
Solubility of thallium(I) bromide, The: A radiochemistry experiment. JOHN C. SHEPPARD AND REILLY C. JENSEN 34
Solutions for qualitative analysis with a cation exchange resin, Preparation of. PAUL KEY, EDWARD SOHL, ROBERT TIEWS, AND CLARK BRICKER 416
Solutions, micellar, Freezing point observations on. ERIC HUTCHINSON AND FUMIKATSU TOKIWA 472
Solvay processes. Tested demonstration A535

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Some aspects of the history of chemistry in Russia. HENRY M. LEICESTER 108
Some experiments on the stoichiometry of reactions. H. R. TIETZE 344
Some models of close packing. RODNEY J. SIME 61
Soviet Union, Abstracting publication on chemical education in the. DAVID A. PATERSON 636
Spectra, Electronic, of transition metal complexes. RICHARD L. CARLIN 135
Spectrograph of moderately high resolution, An inexpensive. RALPH SCHOENBECK AND FREDERICK D. TABBUTT 452
Spectroscopy, Emission. Topics in chemical instrumentation. STEPHEN E. WIBERLY AND HERBERT H. RICHTOL A927
Spectrum of HCl, Vibration-rotation: A physical chemistry experiment. F. E. STAFFORD, C. W. HOLT, AND G. L. PAULSON 245
Sphere, Tangent-, models of molecules: I. Theory and construction. HENRY A. BENT 446
II. Uses in teaching 523
Sponsorship of committee on nuclear science —NAS-NRC. R. E. BALLOU 618
Stability of H_2Se, The thermal. Textbook errors, 42. KENNETH E. HAYES AND NADINE R. M. HAASE 149
Stable gaseous species at high temperatures. BERNARD SIEGEL 304
Standard ionic crystal structures. WILLIAM G. GEHMAN 54
Static and kinetic measurements of an equilibrium constant: A physical-inorganic chemistry experiment. DOYLE BRITTON AND Z. Z. HUGUS, JR. 607
Statistical thermodynamics
Theory of liquids 562
Stereochemistry in the terminal course. GORDON G. EVANS 438
Stereochemistry of (−) menthol, The: An organic laboratory experiment. HARMON C. DUNATHAN 205
Stirrer, Magnetic: Instrument for the freshman laboratory. W. H. SLABAUGH 642
Stoichiometry of reactions, Some experiments on the. H. R. TIETZE 344
Stopcock, A simple pressure. ROGER GILMONT 432
Strain energy, 1. Structure and. Cyclobutane chemistry. ARMIN WILSON AND DAVID GOLDHAMER 504
Structural chemistry
Benzene clathrate 646
Clathrates 643
Close packing models 61
Cyclobutane 504, 599
Electrostatic chemical forces 649
Graphite 117
Hydrogen bonds 598
Inert gas compounds 277
Ionic crystals 54
Molecular orbitals 401
Plastic Dreiding models 457
Solid state 489
Tangent-sphere models 446, 523
VSEPR theory 295
Structure theory of liquids, Significant. HENRY EYRING AND R. P. MARCHI 562
Structures, Rules for molecular oribital. HERBERT MEISLICH 401
Student and teacher, Both can benefit. JAY A. YOUNG 11
Student preparation and manipulation of a gas—methyl ethyl ether. JOSEPH CASANOVA, JR. 41
Sulfides, A simple separation of the group II-A. T. A. O'DONNELL 415
Sulfite, Detection of nitrite and: Iodide ion as a qualitative reagent. ARMINE D. PAUL AND JOHN A. GIBSON, JR. 417
Superoxides, The inorganic. A. W. PETROCELLI AND D. L. KRAUS 146
Surface active compounds by foam fractionation, Separation of. R. M. SKOMOROSKI 470
Survey, Report of a: The present and future of qualitative analysis. NELSON W. HOVEY 410
Symposia
Programed instruction 11
Kinetics for the undergraduate 573
Syntheses, Project, for organic laboratory courses. STANLEY C. BUNCE 174
Systematic errors in the determination of association constants, Random and. R. A. PASTERNAK AND A. P. BRADY 254

Tangent-sphere models of molecules, I. Theory and construction. HENRY A. BENT 446
II. Uses in teaching 523
Tantalum and platinum-clad tantalum electrodes for depositions, Using. EUGENE D. OLSEN, R. F. HAKIN, AND W. J. BLAEDEL 320
Teacher, and student, Both can benefit. JAY A. YOUNG 11
Teaching, chemistry, Programing as an effective aid to. G. R. BAKKER, O. T. BENFEY, AND W. J. STRATTON 18
Teaching techniques
Don't ignore Gutenberg 173
Energy in organic chemistry 201
Examination answers (L) 50
Experimental organic laboratory 203
Inexpensive slides ..... 483, (L)667
Introducing thermodynamics 229
Objective tests 107
Programed instruction symposium 11
Tangent-sphere models 523
Technical information, Using Russian. J. G. TOLPIN 430
Technical report writing in freshman chemistry. NELSON MCKAIG, JR. 86
Technical writing
Editorially speaking 283
Pardee's law 92
Temperature controller, A thermistor actuated proportional. BARTON MILLIGAN 263
Temperature dependence of equilibrium: A first experiment in general chemistry BRUCE H. MAHAN 293
Terminal course, Stereochemistry in the. GORDON G. EVANS 438
Ternary systems, Conversion grids for. E. L. HERIC 325
Terpenes to platinum: The chemical career of Lev Aleksandrovich Chugaev. GEORGE B. KAUFFMAN 656
Tested demonstrations. F. B. DUTTON, *Editor*
Chemiluminescence in electrolysis A477
Chromatography A535
Demonstration notes A241
Effect of chloride ion on precipitation of cadmium sulfide A313
Electrolysis of sodium through glass A313
Fog formation A477
Luminescent compounds, i.e., phosphors. A49
Monoclinic sulfur crystals A477
Oxidation of bromide and iodide ions A241
Oxidation of iodine A593
Oxygen in air A477
Paramagnetism A409
Reaction tube for sodium and chlorine, A. A49
Removal of hardness and deionization of water by the ion exchange method A987
Solvay processes A535
Two catalysis reactions: oxidation of NH_3 and decomposition of Na_2O_2 ..... A593
Vapor shadowgraphs A987
Zone refining A409
Tetrahedral angle
Calculation procedure 94
Textbook errors. KAROL J. MYSELS, *Editor*
42. The thermal stability of H_2Se. KENNETH E. HAYES AND NADINE R. M. HAASE 149
43. The decarboxylation of organic acids. JERRY MARCH 212
44. Friedel-Crafts alkylation. KENNETH L. MARSI AND SAMUEL H. WILEN 214
45. Catalytic inhibition by adsorbed hydrogen. S. R. LOGAN 473
46. Deviations from Raoult's law. M. L. MCGLASHAN 516
47. On hydrogen bonds. JERRY DONOHUE 598
Thallium(I) bromide, The solubility of: A radiochemistry experiment. JOHN C. SHEPPARD AND REILLY C. JENSEN 34
ThB-ThC, Growth-decay studies of: Genetically related radionuclides. P. P. PAREKH AND M. SANKAR DAS 354
Theoretical titration error: In potentiometric, asymmetrical precipitation titrations. HOWARD L. CHRISTOPHERSON. 63
Theory and construction, I: Tangent-sphere models of molecules. HENRY A. BENT 446
Theory of the formaldehyde clock reaction, The. PETER JONES AND K. B. OLDHAM 336
Thermal analysis apparatus, differential, Vacuum and controlled atmosphere. WESLEY W. WENDLANDT 428
Thermal analysis, Differential. Topics in chemical instrumentation. SAUL GORDON A87
Thermal stability of H_2Se, The. Textbook errors, 42. KENNETH E. HAYES AND NADINE R. M. HAASE 149
Thermistor actuated proportional temperature controller, A. BARTON MILLIGAN 263
Thermodynamic equations, Mnemonics for. EDWARD T. RADLEY, IRWIN COHEN, AND BROTHER THOMAS MCCULLOUGH, CSC 261
Thermodynamics
Bond energies 143
Bonding calculations 308
Conventions 2
Experiment and calculations from spectra 249
Gas isotherm 485
General chemistry experiment 293
Gibbs-Duhem equation 648
Letter 50
Letters in regard to the Gibbs-Duhem equation (THIS JOURNAL, 39, 527 (1962) 225–8
Maxwell's demon demonstrator 49
Second law 353
Teaching introduction 229
Vapor pressure dependence on total pressure 317
Thermometric titrators. Topics in chemical instrumentation. JOSEPH JORDAN. A5
Thermoregulator, A simple. SAM KATZ 266
Thin layer chromatographic separation of leaf pigments: A rapid demonstration. CHARLES ROLLINS 32
Thin layer chromatography apparatus. ELIZABETH HANSBURY, D. G. OTT, AND J. D. PERRINGS 31
Thin layer chromatography, Separation of plant pigments by. M. H. ANWAR 29
Thin layer chromatography, Terminology of A167
Time in chemistry, Concepts of. O. T. BENFEY 574
Titration curves for simple ion combination reactions, Potentiometric. JAMES A. GOLDMAN 519
Titration error, Theoretical: In potentiometric asymmetrical precipitation titrations. HOWARD L. CHRISTOPHERSON. 63
Titration errors, Calculating. JAMES N. BUTLER 66
Titrators, Thermometric. Topics in chemical instrumentation. JOSEPH JORDAN. A5
TLC on microscope slides. An organic chemistry experiment. M. BENTON NAFF AND ANNA S. NAFF 534
TLC separation of ink pigments. LEONARD F. DRUDING 536
TLC—versatile tool. DONALD C. MALINS AND JOHN C. WEKELL 531
Toledo chemistry placement examination, An evaluation of the. NELSON W. HOVEY AND ALBERTINE KROHN 370
Topics in chemical instrumentation. S. Z. LEWIN, *Editor*
V. Thermometric titrators A5

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VI. Differential thermal analysis..... A87
VII. Chromatography glossary..... A167
VIII. Instrumentation for particle size analysis. Part 1..... A257
Part 2..... A349
Part 3..... A423
IX. Micrometric methods of volume measurement..... A491
X. Emission spectroscopy..... A927
XI. Continuous analysis..... A549
XII. Pressure measurement. Part 1.. A611
Part 2..... A771
Part 3..... A849

TOPS. Tested overhead projection series. HUBERT N. ALYEA.
2. Oxygen
C. Reactions with oxygen gas..... A29
D. Some oxidations...A29, A131, A213
E. Ozone..... A213
3. Hydrogen
A. Historical..... A303
B. Preparation.....A303, A383
C. Physical properties.....A383, A459
D. Reactions of hydrogen..... A459
E. Hydrogen isotopes..... A460
4. Water, acids, bases, salts
A. Water.....A635, A813, A885
B. Acids, bases..... A947
Special devices
Inexpensive overhead projector..... A523
Simplified TOPS kit..... A575
Supplementary devices.....A30, A131, A213, A304, A383, A460, A814, A886

Tracers, Radioactive: George de Hevesy. The flash of genius, 12. ALFRED B. GARRETT..... 36
Transistor, The discovery of the: W. Shockley, J. Bardeen and W. Brattain. The flash of genius, 17. ALFRED B. GARRETT..... 302
Transition elements, Organometallic derivatives of the. HERBERT D. KAESZ.... 159
Transition metal complexes, Electronic spectra of. RICHARD L. CARLIN..... 135
Transport phenomena, A unified kinetic theory description of. ELDON KNUTH 486
Traps, High capacity vapor. JAMES R. KUPPERS..... 242
Two catalysis reactions: Oxidation of NH_3 and decomposition of Na_2O_2. Tested demonstration..... A593
Two-component phase diagrams, A unified quantitative interpretation of. GEORGE L. JONES, JR..... 38

U
Ultra-sensitive mass spectrometer for carbon-14, An. JOHN C. WRIGHT..... 206
Undergraduate research
$KClO_3$ decomposition.....78, (L)94, (L)94
Unified kinetic theory description of transport phenomena, A. ELDON KNUTH.. 486
Unified quantitative interpretation of two-component phase diagrams, A. GEORGE L. JONES, JR..... 38
Uranium minerals by the specific radioactivity of lead, Dating of. A. W. FAIRHALL..... 626
Use of *n*-center bonds, The. GENE B. CARPENTER..... 385
Use of programed instruction at the Air Force Academy, The. JAMES E. BANKS..... 21
Uses for rubber eye-dropper bulbs. MEYER M. MARKOWITZ AND DANIEL P. BORYTA..... 482
Uses of electrical discharges in preparative inorganic chemistry. ALAN G. MASSEY 311
Using Russian technical information. J. G. TOLPIN..... 430
Using tantalum and platinum-clad tantalum electrodes for depositions. EUGENE D. OLSEN, R. F. EAKIN, AND W. J. BLAEDEL..... 320

V
Vacuum and controlled atmosphere differential thermal analysis apparatus. WESLEY W. WENDLANDT..... 428
Vacuum distillation with an all glass rotary evaporator. M. BENTON NAFF AND WILLIAM SPECTOR..... 327
Vacuum sublimation, Apparatus for molecular distillation and. BERNARD LOEV, KENNETH M. SNADER, AND MINERVA F. KORMENDY..... 426
Valence-shell electron-pair repulsion (VSEPR) theory of directed valency, The. R. J. GILLESPIE..... 295
Vapor density apparatus. S. D. CHRISTIAN, H. E. AFFSPRUNG, AND C. LIN..... 323
Vapor pressure with total pressure, The variation of. NORMAN O. SMITH..... 317
Vapor shadowgraphs. Tested demonstration..... A987
Variation of vapor pressure with total pressure, The. NORMAN O. SMITH..... 317
Vibration-rotation spectrum of HCl: A physical chemistry experiment. F. E. STAFFORD, C. W. HOLT, AND G. L. PAULSON..... 245
Victor Meyer apparatus, Modified. G. WILSON DRAKE..... 606
Viscometric characterization of polystyrene, Polymerization kinetics and: A physical chemistry experiment. J. H. BRADBURY..... 465
Viscometric determination of the isoelectric point of a protein. JOHN E. BENSON.. 468
Visiting scientists program in chemistry, The. ROBERT C. BRASTED..... 329
Voltmeter, a vacuum tube: A glass electrode pH meter. HAROLD E. BROWER 85
Volume measurement, Micrometric methods of. Topics in chemical instrumentation. ROGER GILMONT..... A491
Volumetric analysis, Inorganic reactions mechanisms by: Oxidation of iodide ion. G. J. MOODY AND J. D. R. THOMAS.... 151
(VSEPR) theory of directed valency, The valence-shell electron-pair repulsion. R. J. GILLESPIE..... 295

W
Water activity, Control and measurement of. S. D. CHRISTIAN, H. E. AFFSPRUNG, J. R. JOHNSON, AND J. D. WORLEY..... 419
Wave mechanical treatment of the harmonic oscillator and rigid rotator, An approximate. RONALD RICH..... 365
Weight burets for the quantitative analysis course. SHIRLEY WALTER GADDIS.... 324
Weissenberg effect with gelatin, Demonstrating the. JAMES H. WIEGAND..... 475
What is humic acid? CORNELIUS STEELINK 379
Who discovered Galvanism? EDWARD F. KOHMAN..... 655
Wiberley, Stephen E. (P)..... A927
Willard F. Libby: Carbon-14 dating. The flash of genius, 13. ALFRED B. GARRETT..... 76
Would Mendeleev have predicted the existence of XeF_4? ROLAND WARD..... 277
Writing, Technical report, in freshman chemistry. NELSON MCKAIG, JR..... 86

XeF_4?, Would Mendeleev have predicted the existence of? ROLAND WARD..... 277

Zenchelsky, Seymour T. (P)..... A611
Zone refining apparatus, Low temperature. MORRIS ZIEF, HOLLISTER, RUCH, AND CHARLES H. SCHRAMM..... 351
Zone refining of organic substances, Automatic apparatus for. EUGENIUSZ T. KNYPL AND KASIMIERZ ZIELEŃSKI.... 352
Zone refining. Tested demonstration..... A409

LETTERS TO THE EDITOR

AROTSKY, J. (L)..... 270
BATTINO, RUBIN (L).....50, 667
BRESCIA, FRANK (L)..... 93
BROADBANK, R. W. C., HARDING, R. D., AND PATEL, S. J. (L)..... 328
CARROLL, J. J., AND HAMILTON, R. D. (L).. 93
CAUGHLAN, CHARLES N. (L)..... 229
CHANG, J. C. (L)..... 388
COCKBURN, B. L. (L)..... 94
CONDON, F. E. (L)..... 225
CORSARO, GERALD (L)..... 328
CRAWFORD, CRAYTON M. (L)..... 440
DAY, JESSE H. (L)..... 229
DE MENT, JACK (L)..... 667
GERMONT, ROGER (L)..... 226
HAMILTON, R. D.—*See* CARROLL, J. J.
HARDING, R. D.—*See* BROADBANK, R. W. C.
HAYES, JOHN R. (L)..... 93
HOVEY, NELSON W. (L)..... 270
JURALE, BERNARD (L)..... 94
LINDE, CHARLOTTE (L)..... 270
LORIMER, J. W. (L)..... 227
MARSHALL, JOHN C.—*See* RAMETTE, RICHARD W.
MEYER, E. GERALD, AND WEAVER, ELBERT C. (L)..... 94
MILLER, SIDNEY I.—*See* O'FERRALL, R. A. MORE
MISSEN, R. W., AND SPINNER, I. H. (L)..... 228
NASH, LEONARD K. (L)..... 168
O'FERRALL, R. A. MORE, AND MILLER, SIDNEY I. (L)..... 269
PATEL, S. J.—*See* BROADBANK, R. W. C.
RACUSEN, DAVID (L)..... 229
RAMETTE, RICHARD W., AND MARSHALL, JOHN C. (L)..... 327
ROGERS, D. W. (L).....225, 228
SAMPEY, JOHN R. (L).....228, 388
SCHLEYER, PAUL VON R. (L)..... 270
SHERMA, JOSEPH (L)..... 229
SNATZKE, G. (L)..... 94
SONG, PILL-SOON (L)..... 555
SPINNER, I. H.—*See* MISSEN, R. W.
STRONG, LAURENCE E. (L)..... 50
SWAYZE, DONALD R. (L)..... 269
TUNG, CHEN TA (L)..... 388
VERBIT, LAWRENCE P. (L)..... 92
WEAVER, ELBERT C.—*See* MEYER, E. GERALD
WU, CHISUNG (L)..... 388

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BOOKS REVIEWED

TITLES

Absorption spectra and chemical bonding in complexes. C. K. Jørgensen A142
Absorption spectroscopy, Infrared. Koji Nakanishi 616
Advanced inorganic chemistry: A comprehensive text. F. Albert Cotton and G. Wilkinson 230
Advances in carbohydrate chemistry. Vol. 17. Melville L. Wolfrom and R. Stuart Tipson, *Editors* A597
Advances in chemical physics. Vols. 4 and 5. I. Prigogine, *Editor* 616
Advances in clinical chemistry. Vol. 5. Harry Sobotka, *Editor* A835
Advances in enzymology, Vol. 25 F. F. Nord, *Editor* A985
Advances in fluorine chemistry. Vol. 3. M. Stacey, J. C. Tatlow, and A. G. Sharpe, *Editors* A597
Advances in heterocyclic chemistry. Vol. 1. A. R. Katritzky, *Editor* 559
Advances in inorganic chemistry and radiochemistry. Vol. 4. H. J. Emeléus and A. G. Sharpe, *Editors* A238
Advances in mass sprectrometry. Vol. Z. R. M. Elliott, *Editor* A985
Advances in organic chemistry: Methods and results. Vol. 3. Ralph A. Raphael, Edward C. Taylor, and Hans Wynberg, *Editors* 444
Advances in petroleum chemistry and refining. John J. McKetta, Jr., *Editor*
Vol. 5 . . . . A320
Vol. 6 . . . . A532
Advances in physical organic chemistry. Vol. 1. V. Gold, *Editor* 670
Advances in protein chemistry. Vol. 17. C. B. Anfinsen, Jr., *et al.*, *Editors* A597
Advances in spectroscopy. Vol. 2. H. W. Thompson, *Editor* 170
Alliages métalliques. Vol. 20. Nouveau traité de chemie minérale. Paul Pascal, *General Editor*
Part 1 232
Part 2 . . . . A906
Analysis, Elementary quantitative. W. J. Blaedel and V. W. Meloche 614
Analysis including elementary instrumental analysis. A text-book of quantitative inorganic. Arthur I. Vogel A68
Analysis, Qualitative anion-cation: An interpretative laboratory text of semimicro procedure in basic college chemistry. Emil J. Margolis 390
Analysis, Standard methods of chemical. Vols. 2A and 2B, industrial and natural products and noninstrumental methods. Frank J. Welcher 560
Analysis, The electrochemical methods of: Electrochemical reactions. G. Charlot, J. Badoz-Lambling, and B. Trémillon 560
Analysis via functional groups, Quantitative organic. Sidney Siggia 670
Analytical chemistry, 1962: The proceedings of the international symposium held at Birmingham University, April, 1962. Philip W. West, A. M. G. MacDonald, and T. S. West, *Editors* 615
Analytical chemistry, Fundamentals of. Douglas A. Skoog and Donald M. West 614
Analytical chemistry, Handbook of. Louis Meites 560
Analytical chemistry, Ion exchange separations in. Olof Samuelson A669
Analytical Chemistry, The application of organic bases in. E. A. Ostroumov (D. A. Paterson, *Translator*) A318
Analytical chemistry, Treatise on. Part II, Analytical chemistry of the elements. I. M. Kolthoff, Philip J. Elvin G, and Ernest B. Sandell, *Editors*
Vols. 2, 9 . . . . A679
Vol. 8 . . . . A985
Analytischen chemie, Radioaktive isotope in der. L. M. Michejeva and N. B. Michejev (Hermann Jäger, *Translator;* Gisbert Grossman, *Editor*) 444
Anorganischen chemie, Gmelins handbuch der. 8th edition. E. H. E. Pietsch, *Editor.*
System 28: Calcium, part B, section 3 . . . 171
System 52: Chromium, part A, section 1 . 171
Application of organic bases in analytical chemistry, The. E. A. Ostroumov (D. A. Paterson, *Translator*) A318
Atomic-absorption spectrophotometry. W. T. Elwell and J. A. F. Gidley A54
Atomic and molecular structure, Vol. 1. Comprehensive biochemistry. Marcel Florkin and Elmer H. Stotz, *Editors.* A674
Atomic structure and bonding: A basic systems program. Charles R. Dawson, *Editor* 500
Atoms and molecules, Orbitals in. Chr. Klixbüll Jørgensen 231

Bacteria, Pentose metabolism in. B. L. Horecker A906
Basic chemistry problems for high school. John W. Sulcoski and Stephen Rituper 616
Basic concepts of nuclear chemistry. Ralph T. Overman 499
Basic experimental organic chemistry. James Cason and Henry Rapoport . . 106
Basic principles and calculations in chemical engineering. David M. Himmelblau. A322
Biochemical analysis, Methods of. Vol. II. David Glick, *Editor* A835
Biochemical applications of gas chromatography. H. P. Burchfield and Eleanor E. Storrs 105
Biochemical frontiers in medicine. Harris Busch, *Editor* A598
Biochemistry, Comparative. A comprehensive treatise. Vol. 4. Constituents of life, Part B. Marcel Florkin, and Howard S. Mason, *Editors* A316
Vol. 5. Constituents of life, Part C A985
Biochemistry, Comprehensive. Marcel Florkin and Elmer H. Stotz
Vol. 1. Atomic and molecular structure. A 74
Vol. 2. Organic and physical chemistry . A226
Vol. 3. Methods for the study of molecules A674
Vol. 4. Separation methods A674
Vol. 7. Proteins, Part 1 . . . . A985
Vol. 9. Pyrrole pigments, isoprenoid compounds, phenolic plant constituents A681
Vol. 10 . . . . A681
Vol. 11. Water soluble vitamins, hormones, antibiotics A681
Biochemistry, Horizons in; Albert Szent-Györgyi dedicatory volume. Michael Kasha and Bernard Pullman, *Editors* A218
Biochemistry, Molecular. Edward M. Kosower 172
Biochemistry, Outlines of. Eric E. Conn and P. K. Stumpf A833
Biochemistry, Practical clinical. Harold Varley A834
Biological chemistry, Elements of general and: An introduction to the molecular basis of life. John R. Holum 441
Biological chemistry, Essentials of. James J. Fairley and Gordon L. Kilgour . . A900
Biological research, Physical techniques in. Vol. IV, Special methods. William L. Nastuk, *Editor* A673
Bonding and the geometry of molecules, Chemical. George E. Ryschkewitsch 441
Boranes, Borax to. Robert Gould, *Editor* A66
Borax to boranes. Robert Gould, *Editor*. A66

Calcium, part B, section 3, System 28. Gmelins handbuch der anorganischen chemie. 8th edition. E. H. E. Pietsch, *Editor* 171
Calculations, Basic principle and, in chemical engineering. David M. Himmelblau A322
Calculations, Chemical. Sidney W. Benson 499
Calculations in physical chemistry. B. W. V. Hawes and B. H. Davies A827
Carbohydrate chemistry, Advances in. Vol. 17. Melville L. Wolfrom and R. Stuart Tipson, *Editors* A597
Carbohydrate chemistry, Methods in. Vol. 1, Analysis and preparation of sugars. Roy L. Whistler and M. L. Wolfrom, *Editors* A394
Carbon compounds, Chemistry of. Vol. 5, Miscellaneous. General index. E. H. Rodd, *Editor* 444
Catalysis by metals. G. C. Bond A416
Chem Sources. 4th edition 172
Chemical bonding and the geometry of molecules. George E. Ryschkewitsch 441
Chemical calculations. Sidney W. Benson 499
Chemical dictionary, Dictionnaire de chimie: Fachwörterbuch der chemie: Jean Fouchier and Fernand Billet 336
Chemical engineering, Modern. Vol. 1, Physical operations. Andreas Acrivos, *Editor* A980
Chemical physics, Advances in. Vols. 4 and 5. I. Prigogine, *Editor* 616
Chemical thermodynamics, Elements of. L. K. Nash . . . . 51, (L) 168
Chemistry 1: Atomic structure and bonding: A basic systems program. Charles R. Dawson, *Editor*
Chemistry 1: Response book.
Chemistry 1: Teachers manual 500
Chemistry for the applied sciences. Katherine Blood Hoffman 498
Chemistry of carbon compounds. Vol. 5, Miscellaneous. General index. E. H. Rodd, *Editor* 444
Chemistry of organic fluorine compounds. Milos Hudlický A472
Chemistry of rhenium. K. B. Lebedev . . . A974
Chemistry of the lanthanides, The. Therlad Moeller A830
Chemistry problems. Joseph F. Castka . . 334
Chemists, Great. Eduard Farber, *Editor* A898
Chromatography. Erich Heftmann, *Editor* A63
Chromatography, Gas. D. Ambrose and Barbara Ambrose 104
Chromatography, Gas. Ernst Bayer 104
Chromatography, Gas. John H. Knox . . . 104
Chromatography, Gas-liquid: Theory and practice. Stephen Dal Nogare and Richard S. Juvet, Jr. 104
Chromium, part A, section 3, System 28. Gmelins handbuch der anorganischen chemie. 8th edition. E. H. E. Pietsch, *Editor* 171
Clathrate inclusion compounds. Sister Martinette Hagen A222

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Clinical biochemistry, Practical. HAROLD VARLEY A834
Clinical chemistry, Advances in. Vol. 5. HARRY SOBOTKA, *Editor* A835
Clinical chemistry: Principles and procedures. JOSEPH S. ANNINO A64
Collection of problems in physical chemistry. JIRI BARES, *et al.* (HELENA WATNEY, *Translator*) 502
College chemistry. G. BROOKS KING AND WILLIAM E. CALDWELL 559
Comparative biochemistry: A comprehensive treatise. Vol. 4, Constituents of life, Part B. MARCEL FLORKIN AND HOWARD S. MASON, *Editors* A316
Complex compounds, An introduction to the chemistry of. ALEKSANDER ABRAMOVICH GRINBERG; D. H. BUSCH AND R. F. TRIMBLE, JR., *Editors* (J. ROVTAR LEACH, *Translator*) 282
Complexes, Absorption spectra hand chemical bonding in. C. K. JORGENSEN A142
Comprehensive biochemistry. MARCEL FLORKIN AND ELMER H. STOTZ, *Editors*
Vol. 1. Atomic and molecular structure A674
Vol. 2. Organic and physical chemistry A226
Vol. 3. Methods for the study of molecules A674
Vol. 4. Separation methods A674
Vol. 5. Constituents of life, Part C A985
Vol. 7. Proteins, Part 1 ..... A985
Vol. 9. Pyrrole pigments, isoprenoid compounds, phenolic plant constituents A681
Vol. 10. ..... A681
Vol. 11. Water soluble vitamins, hormones, antibiotics A681
Conservation of energy, Historical roots of the principle of the. ERWIN N. HIEBERT A533
Coordination compounds, Infrared spectra of inorganic and. KAZUO NAKAMOTO. 501
Cosmochemical problems, Some. HAROLD C. UREY A980
Cytology, International review of. Vol. 14. G. H. BOURNE AND J. F. DANIELLI, *Editors* ..... A 598

Debye, Peter, Based on the Harvard lectures of: Topics in chemical physics. ALFRED PROCK AND GLADYS MCCONKEY 502
Developments in inorganic polymer chemistry. M. F. LAPPERT AND G. J. LEIGH, *Editors* A894
Dictionary, Encyclopaedic, of physics. J. THEWLIS, *Editor-in-chief*
Vols. 2–6 105
Vol. 7 390
(Dictionary of chemistry including chemical engineering and fundamentals of allied sciences) Vol. 1, German-English, Fachwörtenbuch der chemie: Einschliesslich verfahrenstechnik und den grundlagen der verwandten wissenschaften. RICHARD ERNST AND INGEBORG ERNST VON MORGENSTERN 336
Dictionnaire de chimie: Fachwörterbuch der chemie: Chemical dictionary. JEAN FOUCHIER AND FERNAND BILLET. 336
Diffraction by matter, Direct analysis of. R. HOSEMANN AND S. N. BAGCHI A142
Direct analysis of diffraction by matter. R. HOSEMANN AND S. N. BAGCHI A142
Displacement reactions. Solvolytic. ANDREW STREITWIESER, JR. A407
Distillation, Multicomponent. CHARLES D. HOLLAND A678
Drug research, Progress in. Vol. 4. ERNST JUCKER, *Editor* A906

Electrochemical reactions: The electrochemical methods of analysis. G. CHARLOT, J. BADOZ-LAMBLING, AND B. TRÉMILLON 560
Electrochemistry: Theoretical principles and practical applications. GIULIO MILAZZO, *Editor* 560
Electronics for scientists: Principles and experiments for those who use instruments. H. V. MALMSTADT, C. G. ENKE, AND E. C. TOREN, JR. 335
Electrons in metals, The wave mechanics of. STANLEY RAIMES A60
Electrons in molecules, Theories of. WILLIAM T. SIMPSON 232
Elementary introduction to molecular spectra. BØRGE BAK A54
Elementary quantitative analysis. W. J. BLAEDEL AND V. W. MELOCHE 614
Elementary solid state physics. CHARLES KITTEL A972
Elements of chemical thermodynamics. L. K. NASH ..... 51, (L) 168
Elements of general and biological chemistry: An Introduction to the molecular basis of life. JOHN R. HOLUM 441
Encyclopaedic dictionary of physics. J. THEWLIS, *Editor-in-chief*
Vols. 2–6 105
Vol. 7, Stellar magnitude to Zwitter ion .. 390
Encyclopedia of chemical technology. Vol. 1, A to Aluminum. ANTHONY STANDEN, *Executive Editor* A677
Engineering, Basic principles and calculations in chemical. DAVID M. HIMMELBLAU A322
Entropy and its applications in science and technology, The significance of the concept of: Entropy. J. D. FAST 442
Entropy: The significance of the concept of entropy and its applications in science and technology. J. D. FAST .. 442
Enzymes, The. Vol. 6, Group transfer; syntheses coupled to ATP cleavage. PAUL D. BOYER, HENRY LARDY, AND KARL MYRBAC, *Editors* A672
Enzymology, Advances in, Vol. 25, F. F. NORD, *Editor* A985
Essentials of biological chemistry. JAMES L. FAIRLEY AND GORDON L. KILGOUR. A900
Excitons, Theory of molecular. A. S. DAVYDOV (MICHAEL KASHA AND MAX OPPENHEIMER, JR., *Translators*) A142
Experimental nuclear chemistry. GREGORY R. CHOPPIN A58
Experimental organic chemistry, Basic. JAMES CASON AND HENRY RAPOPORT. 106
Experimental physical chemistry. FARRINGTON DANIELS, J. W. WILLIAMS, PAUL BENDER, ROBERT A. ALBERTY, AND C. D. CORNWELL A406
Experimentalchemie, Technik der. R. ARENDT AND L. DÖRMER. Revised by KARL-EDMUND DÖRMER AND WALFRIED SEEGER 230
Experiments in chemistry, Semimicro. JOHN W. SULCOSKI A825
Experiments in general, organic, and biological chemistry: A laboratory manual. JOHN R. HOLUM 441
Experiments in physical chemistry. J. M. WILSON, R. J. NEWCOMBE, A. R. DENARO, AND R. M. W. RICKETT 281

Fachwörterbuch der chemie: Einschliesslich verfahrenstechnik und den grundlagen der verwandten wissenschaften (Dictionary of chemistry including chemical engineering and fundamentals of allied sciences), Vol. 1, German-English. RICHARD ERNST AND INGEBORG ERNST VON MORGENSTERN 336
Farben in kultur und leben. HANS KRAMER AND OTTO MATSCHOSS A978
Flotation, Ion. FELIX SEBBA A677
Fluorine and its compounds, The manufacture and use of. A. J. RUDGE A148
Fluorine chemistry, Advancies in. Vol. 3. M. STACEY, J. C. TATLOW, AND A. G. SHARPE, *Editors* A597
Fluorine compounds, Chemistry of organic. MILOS HUDLICKY A472
Fourcroy: Chemist and revolutionary. W. A. SMEATON A396
Functional groups, Quantitative organic analysis via. SIDNEY SIGGIA 670
Fundamentals of analytical chemistry. DOUGLAS A. SKOOG AND DONALD M. WEST 614
Fundamentals of college chemistry. J. H. WOOD, C. W. KEENAN, W. E. BULL, AND N. S. BOWMAN 497
Fundamentals of general chemistry. C. H. SORUM 669

Gas chromatography. D. AMBROSE AND BARBARA AMBROSE 104
Gas chromatography. ERNST BAYER 104
Gas chromatography. JOHN H. KNOX 104
Gas chromatography, Biochemical applications of. H. P. BURCHFIELD AND ELEANOR E. STORRS 105
Gas-liquid chromatography. Theory and practice. STEPHEN DAL NOGARE AND RICHARD S. JUVET, JR. 104
General and biological chemistry, Elements of: An introduction to the molecular basis of life. JOHN R. HOLUM 441
General chemistry. WILLIAM H. NEBERGALL, FREDERIC C. SCHMIDT, AND HENRY R. HOLTZCLAW, JR. 499
General chemistry. Fundamentals of. C. H. SORUM 669
Genetics, Molecular, Part 1. J. HERBERT TAYLOR, *Editor* A528
Geometry of molecules, Chemical bonding and the. GEORGE E. RYSCHKEWITSCH. 441
German-English chemical terminology: Englische und deutsche chemische fachausdrücke. ALEXANDER KING AND HANS FROMHERZ A676
Gmelins handbuch der anorganischen chemie. 8th edition. E. H. E. PIETSCH, *Editor*
System 28: Calcium, part B, section 3 ... 171
System 52: Chromium, part A, section 1 . 171
Great chemists. EDUARD FARBER, *Editor*. A398
Guide to programmed instruction. A. JEROME P. LYSAUGHT AND CLARENCE M. WILLIAMS 500
Guidebook to mechanism in organic chemistry, A. PETER SYKES A224

Halogenverbindungen: Fluorverbindungen und chlorverbindungen. Methoden der organischen chemie. Band V/3. EUGEN MÜLLER, *Editor* A72
Handbook of analytical chemistry. LOUIS MEITES 560
Harvey lectures, The. Series 57. Harvey Society of New York A598
Heterocyclic chemistry, Advances in. Vol. 1. A. R. KATRITZKY 559
High polymers. Vol. 15, Radiation chemistry of polymeric systems. ADOLPHE CHAPIRO, *Editor* A404
High school, Basic chemistry problems for. JOHN W. SULCOSKI AND STEPHEN RITUPER 616
Historical roots of the principle of the conservation of energy. ERWIN N. HIEBERT A533
Historical studies in the language of chemistry. MAURICE P. CROSLAND 336
Horizons in biochemistry: Albert Szent-Györgyi dedicatory volume. MICHAEL KASHA AND BERNARD PULLMAN, *Editors* A218
Hydroboration. HERBERT C. BROWN A72
Hydrodynamics, Physicochemical. VENIAMIN G. LEVICH A827
Hydrogen compounds of the group IV elements. F. G. A. STONE A222
Hyperconjugation. MICHAEL J. S. DEWAR. 232

Inclusion compounds, Clathrate. SISTER MARTINETTE HAGAN A222
Index to reviews, symposia volumes and monographs in organic chemistry for the period 1940–60. NORMAN KHARASCH AND WALTER WOLF, *Editors*, ELAINE C. P. HARRISON, *Technical Editor* A236

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Infrared absorption spectroscopy. KOJI NAKANISHI 616
Infrared spectra of inorganic and coordination compounds. KAZUO NAKAMOTO.. 501
Infrared spectroscopy, An introduction to. W. BRÜGEL (A. R. KATRITZKY AND A. J. D. KATRITZKY, *Translators*) 336
Inorganic and coordination compounds, Infrared spectra of. KAZUO NAKAMOTO 501
Inorganic chemistry, Advanced. A comprehensive text. F. ALBERT COTTON AND G. WILKINSON 230
Inorganic chemistry, Advances in, and Radiochemistry. Vol. 4. H. J. EMÉLEUS AND A. G. SHARPE, *Editors* ... A238
Inorganic chemistry, Introduction to advanced. PHILIP JOHN DURRANT AND BERYL DURRANT 169
Inorganic chemistry, Problems in. HOWARD NECHAMKIN 498
Inorganic chemistry, Progress in. Vol. 3. F. ALBERT COTTON, *Editor* 282
Inorganic chemistry, Structural. A. F. WELLS 280
Inorganic pharmaceutical chemistry, Rogers'. TAITO O. SOINE AND CHARLES O. WILSON A533
Inorganic polymer chemistry, Developments in. M. F. LAPPERT AND G. J. LEIGH, *Editors* A894
Inorganic qualitative analysis: A short course for introductory chemistry. RICHARD B. HAHN AND FRANK J. WELCHER 442
Inorganic syntheses. Vol. 7. JACOB KLEINBERG, *Editor-in-chief* A530
Instrumental analysis, A text-book of quantitative inorganic analysis including elementary. ARTHUR I. VOGEL A68
Instruments, Principles and experiments for those who use: Electronics for scientists. H. V. Malmstadt, C. G. Enke, AND E. C. TOREN, JR. 335
International review of cytology. Vol. 14. G. H. BOURNE AND J. F. DANIELLI, *Editors* A598
Introduction to advanced inorganic chemistry. PHILIP JOHN DURRANT AND BERYL DURRANT 169
Introduction to infrared spectroscopy, An. W. BRÜGEL (A. R. KATRITZKY AND A. J. D. KATRITZKY, *Translators*) 336
Introduction to ligand field theory. CARL J. BALLHAUSEN 390
Introduction to molecular spectroscopy. GORDON M. BARROW A56
Introduction to nuclear science. ALVIN GLASSNER 281
Introduction to organic chemistry. KEITH M. SEYMOUR 335
Introduction to polymer chemistry. JOHN K. STILLE A896
Introduction to polymer chemistry, An. W. R. MOORE A898
Introduction to the chemistry of complex compounds, An. ALEKSANDER ABRAMOVICH GRINBERG; D. H. BUSCH AND R. F. TRIMBLE, JR., *Editors* (J. ROVTAR LEACH, *Translator*) 282
Ion exchange. FRIEDRICH HELFFERICH ... 231
Ion exchange separations in analytical chemistry. OLOF SAMUELSON A669
Ion flotation. FELIX SEBBA A677

Kinetics, Modern chemical. HENRY EYRING AND EDWARD M. EYRING 498

Laboratory operations, Organic chemistry. W. B. RENFROW AND P. J. HAWKINS A402
Laboratory planning for chemistry and chemical engineering. HARRY F. LEWIS, *Editor* 389
Laboratory practice of organic chemistry. G. ROSS ROBERTSON AND THOMAS L. JACOBS 106
Language of chemistry, Historical studies in the. MAURICE P. CROSLAND 363
Lanthanides, The chemistry of. THERALD MOELLER A830
Leben und werk des chemikers Tobias Lowitz: 1757–1804. N. A. FIGUROVSKIJ (E. BIBOW, *Translator*) A400
Lehrbuch der organischen chemie. Vol. 2. 3rd edition. FRIEDRICH KLAGES A234
Life, Constituents of, Part B. Comparative biochemistry: A comprehensive treatise. Vol. 4. MARCEL FLORKIN AND HOWARD S. MASON, *Editors* A316
Part C, Vol. 5 ..... A985
Ligand field theory, Introduction to. CARL J. BALLHAUSEN 390
Lowitz, Tobias: 1757–1804, Leben und werk des chemikers. N. A. FIGUROVSKIJ (E. BIBOW, *Translator*) A400

Macromolecules, Physical chemistry of. CHARLES TANFORD A63
Manufacture and use of fluorine and its compounds, The. A. J. RUDGE A148
Mass spectrometery, Advances in, Vol. 2 Z. R. M. ELLIOTT, *Editor* A985
Mass spectrometry: Organic chemical applications. KLAUS BIEMANN A596
Mechanism in organic chemistry, A guidebook to. PETER SYKES A224
Mechanism of sulfur reactions. WILLIAM A. PRYOR A224
Metabolism in bacteria, Pentose. B. L. HORECKER A906
Métalliques, Alliages. Vol. 20. Nouveau traité de chemie minérale. PAUL PASCAL, *General editor*
Part 1 232
Part 2 ..... A906
Metals, Catalysis by. G. C. BOND A146
Methoden der organischen chemie. Band V/3: Halogenverbindungen: Fluorverbindungen und chlorverbindungen. EUGEN MÜLLER, *Editor* A72
Methods for the study of molecules, Vol. 3. Comprehensive biochemistry. MARCEL FLORKIN AND ELMER H. STOTZ, *Editors*. A674
Methods in carbohydrate chemistry. Vol. 1, Analysis and preparation of sugars. ROY L. WHISTLER AND M. L. WOLFROM, *Editors* A394
Methods of biochemical analysis. Vol. 11. DAVID GLICK, *Editor* A835
Methods of chemical analysis, Standard methods of. Vols. 2A and 2B, Industrial and natural products and non-instrumental methods. FRANK J. WELCHER 560
Methods of experimental physics. Vol. 3. Molecular physics. DUDLEY WILLIAMS, *Editor* A324
Methods of separation, Physical and chemical. EUGENE W. BERG 501
Microbalance techniques, Vacuum. Vol. 3. KLAUS H. BEHRNDT, *Editor* A598
Microscopy, Progress in. Vol. 9. M. FRANÇON A596
Modern chemical engineering. Vol. 1. Physical operations. ANDREAS ACRIVOS, *Editor* A980
Modern chemical kinetics. HENRY EYRING AND EDWARD M. EYRING 498
Modern materials: Advances in development and applications. Vol. 3. H. H. HAUSNER, *Editor* A835
Molecular basis of neoplasia, The A320
Molecular biochemistry. EDWARD M. KOSOWER 172
Molecular excitons, Theory of. A. S. DAVYDOV (MICHAEL KASHA AND MAX OPPENHEIMER, JR., *Translators*) A142
Molecular genetics, Part 1. J. HERBERT TAYLOR, *Editor* A528
Molecular spectra, Elementary introduction to. BORGE BAK A54
Molecular spectroscopy, Introduction to. GORDON M. BARROW A56
Molecules and solids, Quantum theory of, Vol. 1, Electronic structure of molecules. JOHN C. SLATER 615
Molecules, Orbitals in atoms and. CHR. KLIXBÜLL JORGENSEN 231
Molecules, Theories of electrons in. WILLIAM T. SIMPSON 232
Multicomponent distillation. CHARLES D. HOLLAND A678

Neoplasia. The molecular basis of A320
Non-scientist, Science for the. A. R. PATTON A530
Nouveau traité de chimie minérale. PAUL PASCAL, *General editor*
Vol. 8. Germanium, étain, plomb A832
Vol. 9. Titane, zirconium, hafnium and thorium A829
Vol. 15. Part 3. Transuraniens 232
Vol. 20. Part 1. Alliages métalliques .. 232
Vol. 20. Part 2. Alliages métalliques .. A906
Nuclear chemistry, Basic concepts of. RALPH T. OVERMAN 499
Nuclear chemistry, Experimental. GREGORY R. CHOPPIN A58
Nuclear physics and the fundamental particles. HARRY H. HECKMAN AND PAUL W. STARRING 615
Nuclear science, Introduction to. ALVIN GLASSNER 281

On divers arts: The treatise of Theophilus. JOHN G. HAWTHORNE AND CYRIL STANLEY SMITH A904
Orbitals in atoms and molecules. JORGENSEN, CHR. KLIXBÜLL 231
Organic analysis via functional groups, Quantitative. SIDNEY SIGGIA 670
Organic bases in analytical chemistry, The application of. E. A. OSTROUMOV (D. A. PATERSON, *Translator*) A318
Organic chemical applications: Mass spectrometry. KLAUS BIEMANN A596
Organic chemist, Physical aids to the. M. ST. C. FLETT 105
Organic chemistry. DONALD J. CRAM AND GEORGE S. HAMMOND 668
Organic chemistry, A guidebook to mechanism in. PETER SYKES A224
Organic chemistry, Advances in: Methods and results. Vol. 3. RALPH A. RAPHAEL, EDWARD C. TAYLOR, AND AND HANS WYNBERG, *Editors* 444
Organic chemistry, Basic experimental. JAMES CASON AND HENRY RAPOPORT .. 106
Organic chemistry for the period 1940–60, Index to reviews, symposia volumes and monographs in. NORMAN KHARASCH AND WALTER WOLF, *Editors*, ELAINE C. P. HARRISON, *Technical Editor* A236
Organic chemistry, Introduction to. KEITH M. SEYMOUR 335
Organic chemistry laboratory operations. W. B. RENFROW AND P. J. HAWKINS .. A402
Organic chemistry, Laboratory practice of. G. ROSS ROBERTSON AND THOMAS L. JACOBS 106
Organic chemistry, Physical. JACK HINE .. 334
Organic chemistry, Principles of. T. A. GEISSMAN 389
Organic chemistry, Textbook of. ALEXANDER GERO A823
Organic compounds, Reactions of: A textbook for the advanced student. REYNOLD C. FUSON 280
Organic compounds, Structures and reactions of. M. F. GRUNDON AND H. B. HENBEST 670
Organic constituents of higher plants. TREVOR ROBINSON A983
Organic fluorine compounds, Chemistry of. MILOS HUDLICKÝ A472
Organic materials, Radiation effects on. R. O. BOLT AND J. G. CARROLL, *Editors* 669
Organic peroxides: Their formation and reactions. E. G. E. HAWKINS A62
Organic syntheses. Vol. 42, 1962. VIRGIL BOEKELHEIDE, *Editor* 443

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Organischen chemie, Lehrbuch der. Vol. 2. 3rd edition. FRIEDRICH KLAGES..... A234
Organischen chemie, Methoden der. Band V/3: Halogenverbindungen: Fluorverbindungen und chlorverbindungen. EUGEN MÜLLER, *Editor*..... A72
Organophosphorus monomers and polymers. E. L. GEFTER (G. M. KOSOLAPOFF, *Translator*), LEON JACOLEV, *Editor*.... A228
Outlines of biochemistry. ERIC E. CONN AND P. K. STUMPF..... A833
paperback booklist..... A327
Particles, Nuclear physics and the fundamental. HARRY H. HECKMAN AND PAUL W. STARRING..... 615
Pentose metabolism in bacteria. B. L. HORECKER..... A906
Peroxides, Organic: Their formation and reactions. E. G. E. HAWKINS..... A62
Petroleum chemistry and refining, Advances in. JOHN J. MCKETTA, JR., *Editor*
Vol. 5..... A320
Vol. 6..... A532
Pharmaceutical chemistry, Practical: Quantitative analysis. A. H. BECKETT AND J. B. STENLAKE..... A472
Pharmaceutical chemistry, Rogers' inorganic. TAITO O. SOINE AND CHARLES O. WILSON..... A533
Phthalocyanine compounds. F. H. MOSER AND A. L. THOMAS..... A974
Physical aids to the organic chemist. M. ST. C. FLETT..... 105
Physical and chemical methods of separation. EUGENE W. BERG..... 501
Physical chemistry. ERIC HUTCHINSON... 52
Physical chemistry. GEORGE DUFFEY.... 52
Physical chemistry. MARTIN PAUL..... 51
Physical chemistry. WALTER J. MOORE... 502
Physical chemistry, Calculations in. B. W. V. HAWES AND N. H. DAVIES..... A827
Physical chemistry, Collection of problems in. JIRI BARES, *et al.* (HELENA WATNEY, *Translator*)..... 502
Physical chemistry, Experimental. FARRINGTON DANIELS, J. W. WILLIAMS, PAUL BENDER, ROBERT A. ALBERTY, AND C. D. CORNWELL..... A406
Physical chemistry, Experiments in. J. M. WILSON, R. J. NEWCOMBE, A. R. DENARO, AND R. M. W. RICKETT..... 281
Physical chemistry of macromolecules. CHARLES TANFORD..... A63
Physical organic chemistry. JACK HINE... 334
Physical organic chemistry, Advances in. Vol. 1. V. GOLD, *Editor*..... A972
Physical science: A study of matter and energy. VERNE H. BOOTH..... 501
Physical techniques in biological research. Vol. IV, Special methods. WILLIAM L. NASTUK, *Editor*..... A673
Physicochemical hydrodynamics. VENIAMIN G. LEVICH..... A827
Physics, Advances in chemical. Vols. 4 and 5. I. PRIGOGINE, *Editor*..... 616
Physics and the fundamental particles, Nuclear. HARRY H. HECKMAN AND PAUL W. STARRING..... 615
Physics, Elementary solid state. CHARLES KITTEL..... A983
Physics, Encyclopaedic dictionary of. J. THEWLIS, *Editor-in-chief*
Vols. 2–6..... 105
Vol. 7..... 390
Physics, Methods of experimental. Vol. 3, Molecular physics. DUDLEY WILLIAMS, *Editor*..... A324
Physics, Topics in chemical: Based on the Harvard lectures of Peter Debye. ALFRED PROCK AND GLADYS MCCONKEY..... 502
Plants, Organic constituents of higher. TREVOR ROBINSON..... A983
Polycondensation processes, Polymerization and: A collection of papers based on the symposium on polymerization and polycondensation processes. NORBERT A. J. PLATZER..... A152
Polymer chemistry, An introduction to. W. R. MOORE..... A889
Polymer chemistry, Developments in inorganic. M. F. LAPPERT AND G. J. LEIGH, *Editors*..... A894
Polymer chemistry, Introduction to. JOHN K. STILLE..... A896
Polymer science, Textbook of. FRED W. BILLMEYER, JR..... A670
Polymerization and polycondensation processes: A collection of papers based on the symposium on polymerization and polycondensation processes. NORBERT A. J. PLATZER..... A152
Polymers, High. Vol. 15, Radiation chemistry of polymeric systems. ADOLPHE CHAPIRO, *Editor*..... A404
Polymers, monomers and, Organophosphorus. E. L. GEFTER (G. M. KOSOLAPOFF, *Translator*), LEON JACOLEV, *Editor*..... A228
Practical clinical biochemistry. HAROLD VARLEY..... A834
Practical pharmaceutical chemistry: Quantitative analysis. A. H. BECKETT AND J. B. STENLAKE..... A472
PRINCIPLES OF CHEMISTRY. DONALD C. GREGG..... 000
Principles of organic chemistry. T. A. GEISSMAN..... 389
Principles of radioisotope methodology. GRAFTON D. CHASE AND JOSEPH L. RABINOWITZ..... 443
Problems, Chemistry. JOSEPH F. CASTKA. 334
Problems for high school, Basic chemistry. JOHN W. SULCOSKI AND STEPHEN RITUPER..... 616
Problems in inorganic chemistry. HOWARD NECHAMKIN..... 498
Professional scientist, The: A study of American chemists. ANSELM L. STRAUSS, LEE RAINWATER, MARC J. SWARTZ AND BARBARA G. BERGER..... A470
Program, A basic systems: Atomic structure and bonding. CHARLES R. DAWSON, *Editor*..... 500
Programed instruction for schools and industry. J. L. HUGHES..... 500
Programmed instruction, A guide to. JEROME P. LYSAUGHT AND CLARENCE M. WILLIAMS..... 500
Progress in drug research. Volume 4. ERNST JUCKER, *Editor*..... A906
Progress in inorganic chemistry. Vol. 3. F. ALBERT COTTON, *Editor*..... 282
Progress in microscopy. Vol. 9. M. FRANÇON..... A596
Protein chemistry, Advances in. Vol. 17. C. B. ANFINSEN, JR., *et al.*, *Editors*..... A597
Protein structure. HAROLD A. SCHERAGA. 172
Proteins, Part 1. Comprehensive biochemistry, Vol. 7. MARCEL FLOKKIN AND ELMER H. STOTZ, *Editor*..... A985
Psychological world, Their: Scientists. BERNICE T. EIDUSON..... 171
Pyrrole pigments, isoprenoid compounds, phenolic plant constituents, Vol. 9 Comprehensive biochemistry. MARCEL FLORKIN AND ELMER H. STOTZ, *Editors*. A681

Qualitative analysis, Inorganic: A short course for introductory chemistry. RICHARD B. HAHN AND FRANK J. WELCHER..... 442
Quantitative analysis, Elementary. W. J. BLAEDEL AND V. W. MELOCHE..... 614
Qualitative anion-cation analysis: An interpretative laboratory text of semimicro procedure in basic college chemistry. EMIL J. MARGOLIS..... 390
Quantitative inorganic analysis including elementary instrumental analysis, A text-book of. ARTHUR I. VOGEL..... A68
Quantitative organic analysis via functional groups. SIDNEY SIGGIA..... 670
Quantum theory of molecules and solids. Volume 1, Electronic structure of molecules. JOHN C. SLATER..... 615

Radiation chemistry of polymeric systems, Vol. 15. High polymers. ADOLPHE CHAPIRO, *Editor*..... A404
Radiation effects on organic materials. R. O. BOLT AND J. G. CARROLL, *Editors*. 669
Radioaktive isotope in der analytischen chemie. L. M. MICHEJEVA AND N. B. MICHEJEV (HERMANN JAGER, *Translator*; GISBERT GROSSMANN, *Editor*)... 444
Radiochemistry, Advances in inorganic chemistry and. Vol. 4. H. J. EMÉLEUS AND A. G. SHARPE, *Editors*..... A208
Radioisotope methodology, Principles of. GRAFTON D. CHASE AND JOSEPH L. RABINOWITZ..... 443
Reactions of organic compounds: A textbook for the advanced student. REYNOLD C. FUSON..... 280
Refining, Advances in petroleum chemistry and. Vol. 5. KENNETH A. KOBE AND JOHN J. MCKETTA, JR., JOHN J. MCKETTA, JR., *Editor*..... A320
Residue reviews. Vol. 2. FRANCIS A. GUNTHER, *Editor*..... A598
Reviews, Index to, symposia volumes and monographs in organic chemistry for the period 1940–60. NORMAN KHARASCH AND WALTER WOLF, *Editors*, ELAINE C. P. HARRISON, *Technical Editor*..... A236
Rhenium, Chemistry of. K. B. LEBEDEV.. A974
Rogers' Inorganic pharmaceutical chemistry. TAITO O. SOINE AND CHARLES O. WILSON..... A533
Russian, Scientific. A. HOLT..... A150
Russian-English chemical reader: Russko-Angliiskaya kniga dlya chteniya po khimii. ALEX A. KRAMER..... A675

Salt water purification. K. S. SPIEGLER... A534
Science for the non-scientist. A. R. PATTON..... A530
Science in progress, twelfth series. WALLCE R. BRODE, *Editor*..... 230
Scientific method: Optimizing applied research decisions. RUSSELL L. ACKOFF (with the collaboration of SHIV K. GUPTA AND J. SAYER MINAS)..... A233
Scientific Russian. A. HOLT..... A150
Scientists: Their psychological world. BERNICE T. EIDUSON..... 171
Selected papers. KAJ LINDERSTROM-LANG. A596
Semimicro experiments in chemistry. JOHN W. SULCOSKI..... A825
Semimicro procedure in basic college chemistry, An interpretative laboratory text of: Qualitative anion-cation analysis. EMIL J. MARGOLIS..... 390
Separation methods, Vol. 4. Comprehensive biochemistry. MARCEL FLORKIN AND ELMER H. STOTZ, *Editors*..... A674
Separation, Physical and chemical methods of. EUGENE W. BERG..... 501
Separations in analytical chemistry, Ion exchange. OLOF SAMUELSON..... A669
Silent spring. RACHEL CARSON..... 53
Solid state physics, Elementary. CHARLES KITTEL..... A972
Solids, Quantum theory of molecules and. Vol. 1, Electronic structure of molecules. JOHN C. SLATER..... 615
Solvolytic displacement reactions. ANDREW STREITWIESER, JR..... A407
Some cosmochemical problems. HAROLD C. UREY..... A980
Spectra, Absorption, and chemical bonding in complexes. C. K. JØRGENSEN..... A142
Spectra, Infrared, of inorganic and coordination compounds. KAZUO NAKAMOTO. 501
Spectra, molecular, Elementary introduction to. BØRGE BAK..... A54
Spectrometry, Mass: Organic chemical applications. KLAUS BIEMANN..... A596
Spectrophotometry, Atomic-absorption. W. T. ELWELL AND J. A. F. GIDLEY.... A54
Spectroscopy. S. WALKER AND H. STRAW Vol. 1. Atomic, microwave and radio-

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frequency spectroscopy 443
Vol. 2. Ultra-violet, visible, infra-red, and Raman spectroscopy 443
Spectroscopy, Advances in. Vol. 2. H. W. Thompson, *Editor* 170
Spectroscopy, An introduction to infrared. W. Brügel (A. R. Katritzky and A. J. D. Katritzky, *Translators*) 336
Spectroscopy, Infrared absorption. Koji Nakanishi 616
Spectroscopy, molecular, Introduction to. Gordon M. Barrow A56
Spectroscopy, Theory and applications of ultraviolet. H. H. Jaffé and Milton Orchin A670
Standard methods of chemical analysis. Vols. 2A and 2B, Industrial and natural products and noninstrumental methods. Frank J. Welcher 560
Structural inorganic chemistry. A. F. Wells 280
Structures and reactions of organic compounds. M. F. Grundon and H. B. Henbest 670
Substitution at elements other than carbon. C. K. Ingold A152
Sulfur reactions, Mechanism of. William A. Pryor A224
Szent-Györgyi, Albert, dedicatory volume: Horizons in biochemistry. Michael Kasha and Bernard Pullman, *Editors* A218

Technik der experimentalchemie. R. Arendt and L. Dörmer. (Revised by Karl-Edmund Dörmer and Walfried Seeger) 230
Technology, Encyclopedia of chemical. Vol. 1, A to Aluminum. Anthony Standen, *Executive Editor* A677
Temperature: its measurement and control in science and industry. Vol. 3, Part 2. Applied methods and instruments. A. I. Dahl, *Editor*, Charles M. Herzfeld, *Editor-in-chief* 170
Testing, Tyranny of. Banesh Hoffmann. 107
Textbook of organic chemistry. Alexander Gero A823
Textbook of polymer science. Fred W. Billmeyer, Jr. A670
Text-book of quantitative inorganic analysis including elementary instrumental analysis, A. Arthur I. Vogel A68
Theophilus, The treatise of: On diversarts. John G. Hawthorne and Cyril Stanley Smith A904
Theories of electrons in molecules. William T. Simpson 232
Theory and applications of ultraviolet spectroscopy. H. H. Jaffè and Milton Orchin A670
Theory of molecular excitons. A. S. Davydov (Michael Kasha and Max Oppenheimer, Jr., *Translators*) A142
Thermodynamics, chemical, Elements of. L. K. Nash ..... 51, (L) 168
Topics in chemical physics: Based on the Harvard lectures of Peter Debye. Alfred Prock and Gladys McConkey 502
Transuraniens, Vol. 15, Part 3. Nouveau traité de chemie minérale. Paul Pascal, *General Editor* 232
Treatise on analytical chemistry. Part II, Analytical chemistry of the elements. I. M. Kolthoff, Philip J. Elving, and Ernest B. Sandell, *Editors*
Vols. 2: 9 ..... A679
Vol. 8 ..... A985
Tyranny of testing. Banesh Hoffmann .. 107

Ultraviolet spectroscopy, Theory and applications of. H. H. Jaffè and Milton Orchin A670

Vacuum microbalance techniques. Vol. 3. Klaus H. Behrndt, *Editor* A598
Valence. C. A. Coulson 169

Water soluble vitamins, hormones, antibiotics, Vol. 11. Comprehensive biochemistry. Marcel Florkin and Elmer H. Stotz, *Editors* A681
Wave mechanics of electrons in metals, The. Stanley Raimes A60

AUTHORS

Ackoff, Russell L. (with the collaboration of Shiv K. Gupta and J. Sayer Minas). Scientific method: optimizing applied research decisions A233
Acrivos, Andreas, *Editor*. Modern chemical engineering. Vol. 1. Physical operations A980
Alberty, Robert A.—*See* Daniels, Farrington
Ambrose, Barbara—*See* Ambrose, D.
Ambrose, D., and Ambrose, Barbara. Gas Chromatography 106
Anfinsen, C. B., Jr., *et al.*, *Editors*. Advances in protein chemistry. Vol. 17 ..... A597
Annino, Joseph S. Clinical chemistry: Principles and procedures A64
Arendt, R., and Dörmer, L. (Revised by Dörmer, Karl-Edmund, and Seeger, Walfried.) Technik der experimentalchemie 230

Badoz-Lambling, J.—*See* Charlot, G.
Bagchi, S. N.—*See* Hosemann, R.
Bak, Børge. Elementary introduction to molecular spectra A54
Ballhausen, Carl J. Introduction to ligand field theory 390
Bares, Jiri, *et al.* (Watney, Helena, *Translator*). Collection of problems in physical chemistry 502
Barrow, Gordon M. Introduction to molecular spectroscopy A56
Bayer, Ernst. Gas chromatography 104
Beckett, A. H., and Stenlake, J. B. Practical pharmaceutical chemistry: Quantitative analysis A472
Behrndt, Klaus H., *Editor*. Vacuum microbalance techniques. Vol. 3 ..... A598
Bender, Paul—*See* Daniels, Farrington
Benson, Sidney W. Chemical calculations 499
Berg, Eugene W. Physical and chemical methods of separation 501
Berger, Barbara G.—*See* Strauss, Anselm L.
Bibow, E.—*See* Figurovskij, N. A.
Biemann, Klaus. Mass spectrometry: Organic chemical applications A596
Billet, Fernand—*See* Fouchier, Jean
Billmeyer, Fred W., Jr. Textbook of polymer science A670
Blaedel, W. J., and Meloche, V. W. Elementary quantitative analysis 614
Boekelheide, Virgil, *Editor*. Organic syntheses. Vol. 42, 1962 443
Bolt, R. O., and Carroll, J. G., *Editors*. Radiation effects on organic materials .. 669
Bond, G. C. Catalysis by metals ... A146
Booth, Verne H. Physical science: A study of matter and energy 501
Bourne, G. H., and Danielli, J. F., *Editors*. International review of cytology. Vol. 14 ..... A598
Bowman, N. S.—*See* Wood, J. H.
Boyer, Paul D., Lardy, Henry, and Myrback, Karl, *Editors*. The enzymes. Vol. 6, Group transfer; syntheses coupled to ATP cleavage A672
Brode, Wallace R., *Editor*. Science in progress, twelfth series 231
Brown, Herbert C. Hydroboration A72
Brügel, W. (Katritzky, A. R., and Katritzky, A. J. D., *Translators*). An introduction to infrared spectroscopy 336
Bull, W. E.—*See* Wood, J. H.
Burchfield, H. P., and Storrs, Eleanor E. Biochemical applications of gas chromatography 105
Busch, D. H.—*See* Grinberg, Aleksander Abramovich
Busch, Harris, *Editor*. Biochemical frontiers in medicine A598

Caldwell, William E.—*See* King, G. Brooks
Carroll, J. G.—*See* Bolt, R. O.
Carson, Rachel. Silent spring 53
Cason, James, and Rapoport, Henry. Basic experimental organic chemistry .. 106
Castka, Joseph F. Chemistry problems .. 334
Chapiro, Adolphe, *Editor*. High polymers. Vol. 15, Radiation chemistry of polymeric systems A404
Charlot, G., Badoz-Lambling, J., and Trémillon, B. Electrochemical reactions: The electrochemical methods of analysis 560
Chase, Grafton D., and Rabinowitz, Joseph L. Principles of radioisotope methodology 443
Choppin, Gregory R. Experimental nuclear chemistry A58
Conn, Eric E., and Stumpf, P. K. Outlines of biochemistry A833
Cornwell, C. D.—*See* Daniels, Farrington
Cotton, F. Albert, *Editor*. Progress in inorganic chemistry. Vol. 3 282
—and Wilkinson, G. Advanced inorganic chemistry: A comprehensive text 230
Coulson, C. A. Valence 169
Cram, Donald J., and Hammond, George S. Organic chemistry 668
Crosland, Maurice P. Historical studies in the language of chemistry 336

Dahl, A. I., *Editor*; Herzfield, Charles M., *Editor-in-chief*. Temperature: its measurement and control in science and industry. Vol. 3, Part 2, Applied methods and instruments 170
Dal Nogare, Stephen, and Juvet, Richard S., Jr. Gas-liquid chromatography: Theory and practice 104
Danielli, J. F.—*See* Bourne, G. H.
Daniels, Farrington, Williams, J. W., Bender, Paul, Alberty, Robert A., and Cornwell, C. D. Experimental physical chemistry A406
Davies, N. H.—*See* Hawes, B. W. V.
Davydov, A. S. (Kasha, Michael, and Oppenheimer, Max, Jr., *Translators*). Theory of molecular excitons A142
Dawson, Charles H., *Editor*
Chemistry 1: Atomic structure and bonding: A basic systems program
Chemistry 1: Response book
Chemistry 1: Teachers manual 500
Denaro, A. R.—*See* Wilson, J. M.
Dewar, Michael, J. S. Hyperconjugation. 232
Dörmer, Karl-Edmund—*See* Arendt, R.
Dörmer, L.—*See* Arendt, R.
Duffey, George H. Physical chemistry .. 52
Durrant, Beryl—*See* Durrant, Philip John
Durrant, Philip John, and Durrant, Beryl. Introduction to advanced inorganic chemistry 169

Eiduson, Bernice T. Scientists: their psychological world 171
Elliott, R. M., *Editor*, Advances in mass spectrometry, Vol. 2 ..... A985
Elving, Philip J.—*See* Kolthoff, I. M.
Elwell, W. T., and Gidley, J. A. F. Atomic-absorption spectrophotometry . A54
Emeléus, H. J., and Sharpe, A. G., *Editors*. Advances in inorganic and radiochemistry. Vol. 4 ..... A268
Enke, C. G.—*See* Malmstadt, H. V.
Ernst, Richard, and von Morgenstern,

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INGEBORG ERNST. Fachwörtenbuch der chemie: Einschliesslich verfahrenstechnik und den grundlagen der verwandten wissenschaften (Dictionary of chemistry including chemical engineering and fundamentals of allied sciences), Vol. 1, German-English..... 336
EYRING, EDWARD M.—*See* EYRING, HENRY
EYRING, HENRY, AND EYRING, EDWARD M. Modern chemical kinetics 498

FAIRLEY, JAMES L., AND KILGOUR, GORDON L. Essentials of biological chemistry.. A900
FARBER, EDUARD, *Editor*. Great chemists.. A398
FAST, J. D. Entropy: The significance of the concept of entropy and its applications in science and technology..... 442
FIGUROVSKIJ, N. A. (BIBOW, E., *Translator*). Leben und werk des chemikers Tobias Lowitz:1757–1804..... A400
FLETT, M. ST. C. Physical aids to the organic chemist..... 105
FLORKIN, MARCEL, AND MASON, HOWARD, *Editors*. Comparative biochemistry: A comprehensive treatise. Vol. 4, Constituents of life, part B..... A316
Vol. 5. Constituents of life, Part C... A985
FLORKIN, MARCEL, and STOTY, ELMER H., *Editors*. Comprehensive biochemistry
Vol. 1. Atomic and molecular structure..... A674
Vol. 2. Organic and physical chemistry A226
Vol. 3. Methods for the study of molecules..... A764
Vol. 4. Separation methods..... A674
Vol. 7. Proteins, Part 1..... A985
Vol. 9. Pyrrole pigments, isoprenoid compounds, phenolic plant constituents..... A681
Vol. 10. ..... A681
Vol. 11. Water soluble vitamins, hormones, antibiotics..... A681
FOUCHIER, JEAN, AND BILLET, FERNAND. Dictionnaire de chimie: Fachwörterbuch der chemie: Chemical dictionary..... 336
FRANÇON, M. Progress in microscopy. Vol. 9..... A596
FROMHERZ, HANS—*See* KING, ALEXANDER
FUSON, REYNOLD C. Reactions of organic compounds: A textbook for the advanced student..... 280

GEFTER, E. L. (KOSOLAPOFF, G. M., *Translator*), JACOLEV, LEON, *Editor*. Organophosphorus monomers and polymers..... A228
GEISSMAN, T. A. Principles of organic chemistry..... 389
GERO, ALEXANDER. Textbook of organic chemistry..... A328
GIDLEY, J. A. F.—*See* ELWELL, W. T.
GLASSNER, ALVIN. Introduction to nuclear science..... 281
GLICK, DAVID, *Editors*. Methods of biochemical analysis. Vol. 11..... A835
GOLD, V., *Editor*. Advances in physical organic chemistry. Vol. 1..... 670
GOULD, ROBERT, *Editor*. Borax to Boranes.. A66
GREGG, DONALD C. Principles of chemistry..... 669
GRINBERG, ALEKSANDER ABRAMOVICH; BUSCH, D. H., AND TRIMBLE, R. F., JR., *Editors* (LEACH, J. ROVTAR, *Translator*). An introduction to the chemistry of complex compounds..... 282
GROSSMANN, GISBERT—*See* MICHEJEVA, L. M.
GRUNDON, M. F., AND HENBEST, H. B. Structures and reactions of organic compounds..... 670
GUNTHER, FRANCIS A., *Editor*. Residue reviews. Vol. 2..... A598
GUPTA, SHIV K.—*See* ACKOFF, RUSSELL L.

HAGAN, SISTER MARTINETTE. Clathrate inclusion compounds..... A222
HAHN, RICHARD B., AND WELCHER, FRANK J. Inorganic qualitative analysis: A short course for introductory chemistry..... 442
HAMMOND, GEORGE S.—*See* CRAM, DONALD J.
HARRISON, ELAINE C. P.—*See* KHARASCH, NORMAN
Harvey Society of New York. The Harvey lectures. Series 57..... A598
HAUSNER, H. H., *Editor*. Modern materials: Advances in development and applications. Vol. 3..... A835
HAWES, B. W. V., AND N. H. DAVIES. Calculations in physical chemistry..... A827
HAWKINS, E. G. E. Organic peroxides: Their formation and reactions..... A62
HAWKINS, P. J.—*See* RENFROW, W. B.
HAWTHORNE, JOHN G., AND SMITH, CYRIL STANLEY. On divers arts: The treatise of Theophilus..... A904
HECKMAN, HARRY H., AND STARRING, PAUL W. Nuclear physics and the fundamental particles..... 615
HEFTMANN, ERICH, *Editor*. Chromatography..... A63
HELFFERICH, FRIEDRICH. Ion exchange... 231
HENBEST, H. B.—*See* GRUNDON, M. F.
HERZFIELD, CHARLES M.—*See* DAHL, A. I.
HIEBERT, ERWIN N. Historical roots of the principle of the conservation of energy..... A533
HIMMELBLAU, DAVID M. Basic principles and calculations in chemical engineering..... A322
HINE, JACK. Physical organic chemistry.. 334
HOFFMAN, KATHERINE BLOOD. Chemistry for the applied sciences..... 498
HOFFMANN, BANESH. Tyranny of testing.. 107
HOLLAND, CHARLES D. Multicomponent distillation..... A678
HOLT, A. Scientific Russian..... A150
HOLTZCLAW, HENRY R., JR.—*See* NEBERGALL, WILLIAM, H.
HOLUM, JOHN R. Elements of general and biological chemistry: An introduction to the molecular basis of life..... 441
Experiments in general, organic, and biological chemistry: A laboratory manual..... 441
HORECKER, B. L. Pentose metabolism in bacteria..... A906
HOSEMANN, R., AND BAGCHI, S. N. Direct analysis of diffraction by matter..... A142
HUDLICKÝ, MILOS. Chemistry of organic fluorine compounds..... A472
HUGHES, J. L. Programed Instruction for Schools and Industry 500
HUTCHINSON, ERIC. Physical chemistry... 52

INGOLD, C. K. Substitution at elements other than carbon..... A152

JACOBS, THOMAS L.—*See* ROBERTSON, G. ROSS
JACOLEV, LEON—*See* GEFTER, E. L.
JAFFÈ, H. H., AND ORCHIN, MILTON. Theory and applications of ultraviolet spectroscopy..... A670
JÄGER, HERMANN—*See* MICHEJEVA, L. M.
JØRGENSEN, CHR. KLIXBÜLL. Absorption spectra and chemical bonding in complexes..... A142
Orbitals in atoms and molecules..... 231
JUCKER, ERNST, *Editor*. Progress in drug research. Vol. 4..... A906
JUVET, RICHARD S., JR.—*See* DAL NOGARE, STEPHEN

KASHA, MICHAEL, AND PULLMAN, BERNARD. Horizons in biochemistry: Albert Szent-Györgyi dedicatory volume..... A218
—*See* DAVYDOV, A. S.
KATRITZKY, A. J. D.—*See* BRÜGEL, W.
KATRITZKY, A. R., *Editor*. Advances in heterocyclic chemistry..... 559
—*See* BRÜGEL, W.
KEENAN, C. W.—*See* WOOD, J. H.
KHARASCH, NORMAN, AND WOLF, WALTER, *Editors*, HARRISON, ELAINE C. P., *Technical Editor*. Index to reviews, symposia volumes and monographs in organic chemistry for the period 1940–60..... A236
KILGOUR, GORDON L.—*See* FAIRLEY, JAMES L.
KING, ALEXANDER, AND FROMHERZ, HANS. German-English chemical terminology: Englische und deutsche chemische fachausdrücke..... A676
KING, G. BROOKS, AND CALDWELL, WILLIAM E. College chemistry..... 559
KITTEL, CHARLES. Elementary solid state physics..... A972
KLAGES, FRIEDRICH. Lehrbuch der organischen chemie. Vol. 2. 3rd edition.... A234
KLEINBERG, JACOB, *Editor-in-chief*. Inorganic syntheses. Vol. 7..... A530
KNOX, JOHN H. Gas chromatography..... 104
KOLTHOFF, I. M., ELVING, PHILIP J., AND SANDELL, ERNEST B., *Editors*. Treatise on analytical chemistry. Part II, Analytical chemistry of the elements. Vols. 2 and 9..... A679
Vol. 8..... A985
KOSLOAPOFF, G. M.—*See* GEFTER, E. L.
KOSOWER, EDWARD M. Molecular biochemistry..... 172
KRAMER, ALEX A. Russian-English chemical reader: Russko-Angliiskaya kniga dlya chteniya po khimii..... A675
KRAMER, HANS, AND MATSCHOSS, OTTO. Farben in kultur und leben..... A978

LAPPERT, M. F. AND LEIGH, G. J., *Editors*. Developments in inorganic polymer chemistry..... A894
LARDY, HENRY—*See* BOYER, PAUL D.
LEACH, J. ROVTAR—*See* GRINBERG, ALEKSANDER ABRAMOVICH
LEBEDEV, K. B. Chemistry of rhenium.... A974
LEIGH, G. J.—*See* LAPPERT, M. F.
LEVICH, VENIAMIN G. Physicochemical hydrodynamics..... A827
LEWIS, HARRY F., *Editor*. Laboratory planning for chemistry and chemical engineering 389
LINDERSTRØM-LANG, KAJ. Selected papers A596
LYSAUGHT, JEROME P., AND WILLIAMS, CLARENCE M. A guide to programmed instruction..... 500

MACDONALD, A. M. G.—*See* WEST, PHILIP W.
MALMSTADT, H. V., ENKE, C. G., AND TOREN, E. C., JR. Electronics for scientists: Principles and experiments for those who use instruments..... 335
MARGOLIS, EMIL J. Qualitative anion–cation analysis: An interpretative laboratory text of semimicro procedure in basic college chemistry..... 390
MASON, HOWARD—*See* FLORKIN, MARCEL
MATSCHOSS, OTTO—*See* KRAMER, HANS
MCCONKEY, GLADYS—*See* PROCK, ALFRED
MCKETTA, JOHN J., JR., *Editor*. Advances in petroleum chemistry and refining. Vol. 5..... A320
Vol. 6..... A532
MEITES, LOUIS. Handbook of analytical chemistry..... 560
MELOCHE, V. W.—*See* BLAEDEL, W. J.
MICHEJEV, N. B.—*See* MICHEJEVA, L. M.
MICHEJEVA, L. M., AND MICHEJEV, N. B. (JÄGER, HERMANN, *Translator*; GROSSMANN, GISBERT, *Editor*). Radioaktive isotope in der analytischen chemie..... 444
MILAZZO, GIULIO, *Editor*. Electrochemistry: Theoretical principles and practical applications..... 560
MINAS, J. SAYER—*See* ACKOFF, RUSSELL L.
MOELLER, THERALD. The chemistry of the lanthanides..... A830
MOORE, W. R. An introduction to polymer chemistry..... A898

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MOORE, WALTER J. Physical chemistry . . 502
MOSER, F. H., AND THOMAS, A. L. Phthalocyanine compounds A974
MÜLLER, EUGEN, *Editor*. Methoden der organischen chemie. Band V/3: Halogenverbindungen: Fluorverbindungen und chlorverbindungen A72
MYRBACK, KARL—*See* BOYER, PAUL D.

NAKAMOTO, KAZUO. Infrared spectra of inorganic and coordination compounds 501
NAKANISHI, KOJI. Infrared absorption spectroscopy 616
NASH, L. K. Elements of chemical thermodynamics . . . . . 51, (L)168
NASTUK, WILLIAM L., *Editor*. Physical techniques in biological research. Vol. IV. Special methods A673
NEBERGALL, WILLIAM H., SCHMIDT, FREDERIC C., AND HOLTZCLAW, HENRY R. JR. General chemistry 499
NECHAMKIN, HOWARD. Problems in inorganic chemistry 498
NEWCOMBE, R. J.—*See* WILSON, J. M.
NORD, F. F., *Editor*, Advances in enzymology. vol. 25 . . . . . A985

OPPENHEIMER, MAX. JR.—*See* DAVYDOV, A. S.
ORCHIN, MILTON—*See* JAFFÈ, H. H.
OSTROUMOV, E. A. (PATERSON, D. A., *Translator*). The application of organic bases in analytical chemistry A318
OVERMAN, RALPH T. Basic concepts of nuclear chemistry 499

PASCAL, PAUL, *General editor*. Nouveau traité de chemie minérale
Vol. 8. Germanium, étain, plomb A832
Vol. 9. Titane, zirconium, hafnium and thorium 829
Vol. 15. Part 3. Transuraniens 232
Vol. 20. Part 1. Alliages métalliques . . . 232
Vol. 20. Part 2. Alliages métalliques . . A906
PATERSON, D. A.—*See* OSTROUMOV, E. A.
PATTON, A. R. Science for the non-scientist A530
PAUL, MARTIN. Physical chemistry 51
PIETSCH, E. H. E., AND THE GMELIN INSTITUTE, *Editors*. Gmelins handbuch der anorganischen chemie. 8th edition.
System 28: Calcium, part B, section 3 . . . 171
System 52: Chromium, part A, section 1 . 171
PLATZNER, NORBERT A. J. Polymerization and polycondensation processes: A collection of papers based on the symposium on polymerization and polycondensation processes A152
PRIGOGINE, I., *Editor*. Advances in chemical physics. Vols. 4 and 5 616
PROCK, ALFRED, AND MCCONKEY, GLADYS. Topics in chemical physics: Based on the Harvard lectures of Peter Debye . . . 502
PRYOR, WILLIAM A. Mechanism of sulfur reactions A224
PULLMAN, BERNARD—*See* KASHA, MICHAEL

RABINOWITZ, JOSEPH L.—*See* CHASE, GRAFTON D.
RAMINES, STANLEY. The wave mechanics of electrons in metals A60
RAINWATER, LEE—*See* STRAUSS, ANSELM L.
RAPHAEL, RALPH A., TAYLOR, EDWARD C., AND WYNBERG, HANS, *Editors*. Advances in organic chemistry: Methods and results. Vol. 3 444
RAPOPORT, HENRY—*See* CASON, JAMES
RENFROW, W. B., AND HAWKINS, P. J. Organic chemistry laboratory operations A402
RICKETT, R. M. W.—*See* WILSON, J. M.
RITUPER, STEPHEN—*See* SULCOSKI, JOHN W.
ROBERTSON, G. ROSS, AND JACOBS, THOMAS L. Laboratory practice of organic chemistry 106
ROBINSON, TREVOR. Organic constituents of higher plants A983
RODD, E. H., *Editor*. Chemistry of carbon compounds. Vol. 5, Miscellaneous. General index 444
RUDGE, A. J. The manufacture and use of fluorine and its compounds A148
RYSCHKEWITSCH, GEORGE E. Chemical bonding and the geometry of molecules 441

SAMUELSON, OLOF. Ion exchange separations in analytical chemistry A669
SANDELL, ERNEST B.—*See* KOLTHOFF, I. M.
SCHERAGA, HAROLD A. Protein structure . . 172
SCHMIDT, FREDRIC C.—*See* NEBERGALL, WILLIAM H.
SEBBA, FELIX. Ion flotation A677
SEEGER, WALFRIED—*See* ARENDT, R.
SEYMOUR, KEITH M. Introduction to organic chemistry 335
SHARPE, A. G.—*See* EMÉLEUS, H. J.
—*See* STACEY, M.
SIGGIA, SIDNEY. Quantitative organic analysis via functional groups 670
SIMPSON, WILLIAM T. Theories of electrons in molecules 232
SKOOG, DOUGLAS A., AND WEST, DONALD M. Fundamentals of analytical chemistry 614
SLATER, JOHN C. Quantum theory of molecules and solids. Vol. 1, Electronic structure of molecules 615
SMEATON, W. A. Fourcroy: Chemist and revolutionary A396
SMITH, CYRIL STANLEY—*See* HAWTHORNE, JOHN G.
SOBOTKA, HARRY, *Editor*. Advances in clinical chemistry. Vol. 5 . . . . . A835
SOINE, TAITO O., AND WILSON, CHARLES O. Rogers' inorganic pharmaceutical chemistry A533
SORUM, C. H. Fundamentals of general chemistry 669
SPIEGLER, K. S. Salt water purification . . . A534
STACEY, M., TATLOW, J. C., AND SHARPE, A. G., *Editors*. Advances in fluorine chemistry. Vol. 3 . . . . . A597
STANDEN, ANTHONY, *Executive Editor*. Encyclopedia of chemical technology. Vol. 1, A to Aluminum A677
STARRING, PAUL W.—*See* HECKMAN, HARRY H.
STENLAKE, J. B.—*See* BECKETT, A. H.
STILLE, JOHN K. Introduction to polymer chemistry A896
STONE, F. G. A. Hydrogen Compounds of the Group IV Elements A222
STORRS, ELEANOR E.—*See* BURCHFIELD, H. P.
STOTZ, ELMER M.—*See* FLORKIN, MARCEL
STRAUSS, ANSELM L., RAINWATER, LEE, SWARTZ, MARC J., AND BERGER, BARBARA G. The professional scientist: A Study of American chemists . . . A470
STRAW, H.—*See* WALKER, S.
STREITWIESER, ANDREW, JR. Solvolytic displacement reactions A407
STUMPF, P. K.—*See* CONN, ERIC E.
SULCOSKI, JOHN W. Semimicro experiments in chemistry A825
—AND RITUPER, STEPHEN. Basic chemistry problems for high school 616
SWARTZ, MARC J.—*See* STRAUSS, ANSELM L.
SYKES, PETER. A guidebook to mechanism in organic chemistry A224

TAGGART, CHARLES. Physical chemistry of macromolecules A63
TATLOW, J. C.—*See* STACEY, M.
TAYLOR, EDWARD C.—*See* RAPHAEL, RALPH A.
TAYLOR, J. HERBERT, *Editor*. Molecular genetics, Part 1 . . . . . A528
THEWLIS, J., *Editor-in-chief*. Encyclopaedic dictionary of physics. Vols. 2–6 105
Vol. 7, Stellar magnitude to Zwitter ion . . 390
THOMAS, A. L.—*See* MOSER, F. H.
THOMPSON, H. W., *Editor*. Advances in spectroscopy. Vol. 2 170
TIPSON, R. STUART—*See* WOLFROM, MELVILLE L.
TOREN, E. C., JR.—*See* MALMSTADT, H. V.
TRÉMILLON, B.—*See* CHARLOT, G.
TRIMBLE, R. F., JR.—*See* GRINBERG, ALEXSANDER ABRAMOVICH

UREY, HAROLD C. Some cosmochemical problems A980

VARLEY, HAROLD. Practical clinical biochemistry A834
VOGEL, ARTHUR I. A textbook of quantatative inorganic analysis including elementary instrumental analysis A68
VON MORGENSTERN, INGEBORG ERNST—*See* ERNST, RICHARD

WALKER, S., AND STRAW, H. Spectroscopy
Vol. 1. Atomic, microwave, and radio-frequency spectroscopy 443
Vol. 2. Ultra-violet, visible, infra-red, and Raman spectroscopy 443
WATNEY, HELENA—*See* BARES, JIRI
WELCHER, FRANK J., *Editor*. Standard methods of chemical analysis. Vols. 2A and 2B, Industrial and natural products and noninstrumental methods 560
—*See* HAHN, RICHARD B.
WELLS, A. F. Structural inorganic chemistry 280
WEST, DONALD M.—*See* SKOOG, DOUGLAS A.
WEST, PHILIP W., MACDONALD, A. M. G., AND WEST, T. S., *Editors*. Analytical chemistry, 1962: The proceedings of the international symposium held at Birmingham University, April, 1962 . . . 615
WEST, T. S.—*See* WEST, PHILIP W.
WHISTLER, ROY L., AND WOLFROM, M. L., *Editors*. Methods in carbohydrate chemistry. Vol. 1, Analysis and preparation of sugars A394
WILKINSON, G.—*See* COTTON, F. ALBERT
WILLIAMS, CLARENCE M.—*See* LYSAUGHT, JEROME P.
WILLIAMS, DUDLEY, *Editor*. Methods of experimental physics. Vol. 3, Molecular physics A324
WILLIAMS, J. W.—*See* DANIELS, FARRINGTON
WILSON, CHARLES O.—*See* SOINE, TAITO O.
WILSON, J. M., NEWCOMBE, R. J., DENARO, A. R., AND RICKETT, R. M. W. Experiments in Physical Chemistry 231
WOLF, WALTER—*See* KHARASCH, NORMAN
WOLFROM, MELVILLE L., AND TIPSON, R. STUART, *Editors*. Advances in carbohydrate chemistry. Vol. 17 . . . . . A597
—*See* WHISTLER, ROY L.
WOOD, J. H., KEENAN, C. W., BULL, W. E., AND BOWMAN, N. S. Fundamentals of college chemistry 497
WYNBERG, HANS—*See* RAPHAEL, RALPH A.

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R. Cecil, Intramolecular Bonds in Proteins. I. The Role of Sulfur in Proteins
Harold A. Scheraga, Intramolecular Bonds in Proteins. II. Non-covalent Bonds
AUTHOR INDEX—SUBJECT INDEX.

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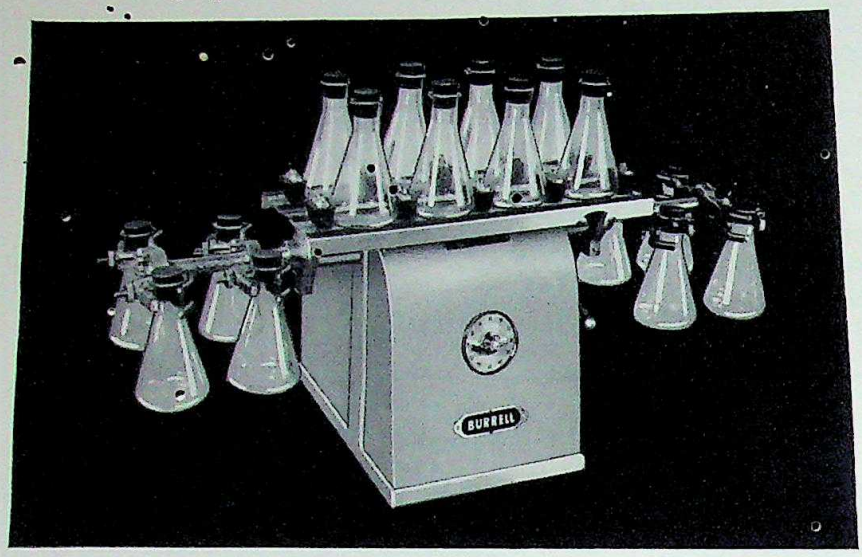

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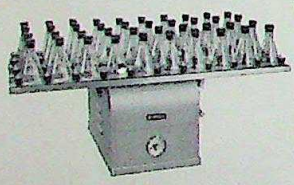

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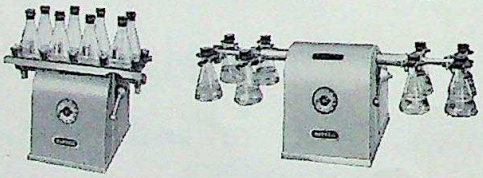

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covered (in 1774), was obtained later by the dehydrogenation of alcohol."

The descriptive chemistry is generally accurate and adequate, although exception may be taken here and there, as in the statement that chloromethane is made by the reaction of an equimolar mixture of methane and chlorine when in fact a large excess of methane is used. Formic acid is described as being made from carbon monoxide and steam, when the important processes are two-step operations.

Minor and irrelevant points are sometimes included. For example, the color, boiling point, and method of preparation of ozone are given. Strain theory and conformation are not touched upon at all.

Problems of IUPAC nomenclature are not adequately handled. The student is given little help in the construction of IUPAC names; apparently he is supposed to learn by inference from examples. Unacceptable hybridization of IUPAC with other style names is found in names such as "1-butyl halides," "isobutene," "the eight isomeric pentanols," and in the phrase "there are two *n*-butanols."

The questions at the end of the chapters are few and unimaginative.

In short, while this book is chemically sound and modern in approach, it leaves something to be desired in the way of organization and polish.

FLOYD L. JAMES
Miami University
Oxford, Ohio

Elementary Solid State Physics

Charles Kittel, University of California, Berkeley. John Wiley and Sons, Inc., New York, 1962. xi + 339 pp. Figs. and tables. 15.5 × 23.5 cm. $8.75.

"Elementary Solid State Physics" is a judiciously edited version of "Introduction to Solid State Physics." The reviewer can find little quarrel with the choice of material for a beginning one-semester course in the physics of solids. All the essential parts and the flavor of "Introduction" have been retained and there is sufficient detail and references to the original literature to give depth to the treatment. The problems at the end of each chapter are often taken over unchanged, but the more difficult starred problems have not been included. Many of the derivations in the Appendix of "Introduction" have been omitted.

Considerable new material, including tunnel diodes, masers, and the strength of metal whiskers, has been included. Users of the second edition of "Introduction" may want to use this more up-to-date version at the cost of using a less sophisticated treatment.

In comparison with Azaroff's "Introduction to Solids" (reviewed in J. CHEM. ED., 38, 586 [1961]), "Elementary Solid State Physics" is much more mathemat-

(*Continued on page A974*)

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By KENNETH B. WIBERG, *Yale University.* Designed as a text for a full-year graduate course, this book concentrates on the physical chemical aspects rather than the organic chemical aspects of organic chemistry. Emphasizing quantitative understanding of the material, the book gives a very detailed coverage of chemical bonding, spectra, equilibria, and kinetics. *1963. Approx. 600 pages. Prob. $10.75.*

ANALYSIS AND CHARACTERIZATION OF OILS, FATS, AND FAT PRODUCTS—Volume I

By H. A. BOEKENOOGEN, *Technical University Eindhoven, The Netherlands.* The first in a series of monograph collections covering important advances in the rapidly changing field of chemical analysis, Volume I includes a general description of those classical methods in fat analysis which are still valuable and a critical survey of techniques for analyzing the most essential fatty acid, linoleic acid, and other analytical methods. An Interscience Book. *1963. Approx. 350 pages. Prob. $12.00.*

AMERICAN CHEMICAL SOCIETY SYMPOSIUM ON MORPHOLOGY OF POLYMERS

Edited by T. G. ROCHOW, *American Cyanamid Company.* Includes the papers presented at a symposium held at Los Angeles, April 4–5, 1963. The symposium was organized so that the parameters of morphology, composition and properties are considered on four levels of *macromolecular organization.* The topics are macromolecular domains, morphology of surfaces, the crystalline phase, and the polyphase systems. (Journal of Polymer Science, Part C. POLYMER SYMPOSIA, No. 3). An Interscience Publication. *1963. Approx. 144 pages. Prob. $6.00.*

HIGH SPEED TESTING Volume IV

Co-Chairmen: A. G. H. DIETZ, *Massachusetts Institute of Technology; and* FREDERICK R. EIRICH, *Polytechnic Institute of Brooklyn.* This volume is based on the Fourth Annual Symposium on High Speed Testing, held in Boston, May 15–16, 1963, and sponsored by the Plas-Tech Equipment Corporation. It explores the latest developments in theory, instrumentation, test techniques, interpretation of test data, and application of results. An Interscience Book. *1963. Approx. 280 pages. Prob. $11.00.*

GENERAL CHEMISTRY, A PROGRAMMED REVIEW

By LUCIANA SACERDOTE, *Columbia University.* Employs the powerful new technique of programmed teaching as the basis for a thorough, comprehensive review of chemical principles and the physicochemical properties and reactions of the elements. *1963. Approx. 336 pages. $4.75.*

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ical and more concerned with the physicists's point of view rather than that of the materials scientist.

RICHARD C. CARLSTON
Aerojet-General Corporation
Azusa, California

The Chemistry of Rhenium

K. B. Lebedev, translated by *L. Ronson* in collaboration with *A. A. Woolf*. Butterworths, London, 1962. x + 105 pp. Figs. and tables. 14 × 22 cm. $7.50.

This short volume differs from the previous monographs of Tribalat (1957) and Druce (1948) in that the main emphasis is on the occurrence, separation, and production of the element. The only chemistry considered is that related to production processes. Since the original Russian publication is based on the literature up to 1959, this volume is already slightly out of date. Although naturally the Russian practice is emphasized, the foreign literature is adequately covered. Information on the prediction, and discovery of rhenium are very briefly covered in Chapter I. Chapter II contains considerable detail on the properties of rhenium metal, its alloys, oxides, and perrhenates; while the uses of rhenium are discussed in Chapter III. Production data are also included in Chapter III, although the data for Russia are curiously missing. The geochemistry of rhenium and the recovery of rhenium from molybdenum sources are discussed in Chapter IV. The methods used for the extraction of rhenium compounds, complete with flow sheets, are discussed in Chapter V. Chapter VI is devoted to methods of reduction to the element. Chapter VII briefly deals with the analytical chemistry. Although the reviewer cannot vouch for the accuracy of the translation, the English version certainly is readable. The average chemist probably will not be interested in purchasing this book unless he is specifically interested in this element.

EDWIN M. LARSEN
University of Wisconsin
Madison

Phthalocyanine Compounds

Frank H. Moser and *Arthur L. Thomas*, Standard Ultramarine and Color Co., Huntington, West Virginia. ACS Monograph No. 157. Reinhold Publishing Corp., New York, 1963. xiii + 365 pp. Figs. and tables. 16 × 23.5 cm. $18.

The only chromophore discovered to date in the 20th century is "Phthalocyanine." The name, coined by R. P. Linstead, means "rock oil dark blue." The authors have performed a major service by condensing its literature, to mid-April, 1962, into book form. Long lists of references follow each chapter.

(*Continued on page A976*)

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RETRIEVAL GUIDE TO THERMOPHYSICAL PROPERTIES RESEARCH LITERATURE, Vol. 2 (Books 1,2,3)

Edited By Y. S. TOULOUKIAN, Director, Thermophysical Properties Research Center. Off press.

This second volume extends the work of the Center to provide an additional 10,000 references to the seven thermophysical properties covered in Volume I. Book 1 is a classified Director of Substances, and also contains several indexes and guides which greatly enhance its usefulness. Book 2 contains classified code entries for the seven properties. Part A of book 3 provides bibliographic citations covering journals as well as university dissertations and government and industrial reports. Part B contains an index of contributing authors.

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By DONALD J. CRAM, University of California, Los Angeles; and GEORGE S. HAMMOND, California Institute of Technology. 768 pages, $10.75.

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INTRODUCTION TO BIOPHYSICAL CHEMISTRY

By R. BRUCE MARTIN, University of Virginia. Available in January, 1964.

This new text covers the application of fundamental principles to small molecules of biological significance, including the methods for characterizing biopolymers and a study of their properties and interrelationships. Among the topics: the thermodynamic basis of biological reactions, a systematic presentation of acid-base equilibria, and the properties, functions, and interrelationships of biologically important macromolecules, proteins, and nucleic acids.

GROUP THEORY AND QUANTUM MECHANICS

By MICHAEL TINKHAM, University of California, Berkeley. International Series in Pure and Applied Physics. Available in January, 1964.

This new volume presents the elements of group theory most pertinent to physical applications and provides a brief but systematic analysis of the quantum mechanics of atoms, molecules, and solids, emphasizing the use of group theoretical techniques. Features: a lucid presentation of the calculation of energy levels and selection rules. . .a treatment of the magnetic groups with illustrative applications to real magnetic groups. . .exercises follow each chapter.

CRYSTALLIZATION OF POLYMERS

By LEO MANDELKERN, Florida State University. McGraw-Hill Series in Advanced Chemistry. 320 pages, $11.00.

This definitive work reviews and examines critically the state of knowledge of the phenomena of crystallization of polymers. All classes and types of macromolecules are considered from the standpoint of the basic disciplines of chemistry and physics. Emphasis is on fundamental scientific concepts.

CHEMISTRY, Second Edition

By M. J. SIENKO and R. A. PLANE, Cornell University. 623 pages $7.95.

A careful revision and improvement of this excellent textbook in college chemistry. Neither the character or the scope of the book has been changed, but the authors, with a multitude of reviewers, have reexamined and strengthened the first edition. The changes result in increased depth and lucidity rather than increased size. The aim of the book, as before, is to present an introductory course which is quantitative, up to date, and of sufficient rigor to prepare the student for further work in the field.

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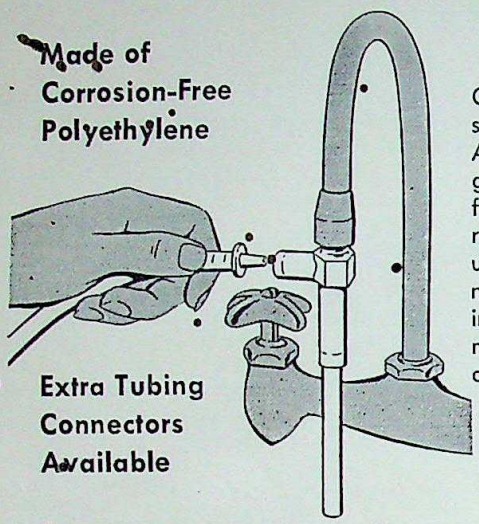

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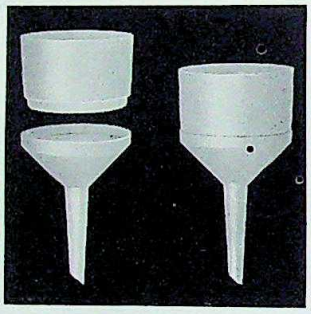

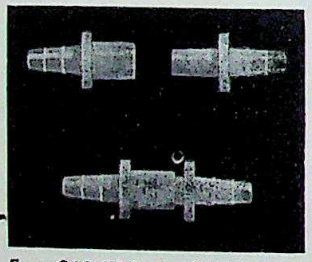

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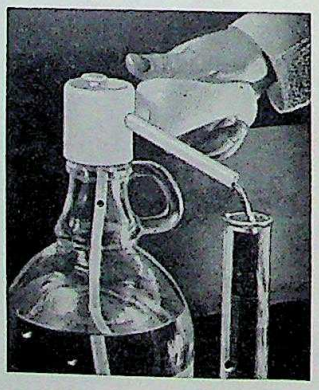

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The first two chapters give a brief account of the accidental discovery of this useful pigment, and detail the determination of the structure of the phthalocyanines and their relation to chlorophyll and hemin. The physical properties of phthalocyanines are described in terms of X-ray crystal data; the importance of, and the differences between, the alpha, beta, and gamma forms of the pigment are explained. Discussed among other aspects are the optical, electrical, and photochemical behavior. Chapters 3 and 4 review the numerous ways of preparing phthalocyanine and its derivatives on laboratory and factory scales. Finishing processes needed for maximum color development are described.

Dyes form the subject of Chapter 5. Attachment of various substituents on the phthalocyanine ring make the products soluble in either organic or aqueous solvents. Cobalt phthalocyanine is the preferred raw material for preparing vat dyes in commercial use. Colors fall into the blue-green end of the spectrum.

Commercial applications (Chapter 6) of phthalocyanines divide into two categories. Colorant uses cover paint, plastics, printing inks, rubber, and textiles. Non-colorant uses list such items as catalysts, gelation of oils to greases, analytical chemistry, medical and biological, electrical, and nuclear reactor systems. Here the pigment protects lubricants against high energy neutron irradiation.

The last two chapters concern modifications made in the fundamental porphyrin nucleus. Three types of phthalocyanine polymers are reviewed. The first has simple C–C bonds of the diphenyl type linking adjacent phthalo rings. The second type has a methylene, or equivalent, unit connecting the phthalo rings; in the last, adjacent units share phenylene rings in common.

Appendixes (3) provide a good general bibliography to the phthalocyanines; a series of testing and analytical procedures; and a portion of the *Colour Index* giving C. I. name, number, trade name, and manufacturer of various pigments. Author and subject indexes complete the book.

Phthalocyanines have esthetic values, but nowhere in the book will one find color plates to illustrate the raw and the finished pigment; the effect of chemical modification, or the influence of crystal form and particle size on the tinctorial values. In view of the excellent color printing available today, the absence of color plates is lamentable. On the chemical side the book is nearly silent concerning mechanisms by which phthalocyanine formation takes place. No mention is made of reaction kinetics or order.

A short glossary of terms peculiar to the dye, pigment, and textile industries would help a novice in this field. The writers provide authenticity for their story by numerous direct quotations from the sources in English, French, and German. Since patents form a large portion of the

(*Continued on page A978*)

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Spring 1964, Approximately 600 pages, probably $7.50

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FREE RADICAL REACTIONS IN PREPARATIVE ORGANIC CHEMISTRY

By **George Sosnovsky,** Illinois Institute of Technology

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Current applications involving saturated and unsaturated long-chain fatty acids are covered in this study. It also treats newly-developed methods that are suitable for polyfunctional compounds and for steroids, giving summaries of original work from the authors' laboratories. The book will be of special interest to biologists and biochemists.

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By **G. Ross Robertson** and **Thomas Jacobs,** University of California at Los Angeles

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1962, 391 pages, $5.75

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1962, 320 pages, paper, $4.25

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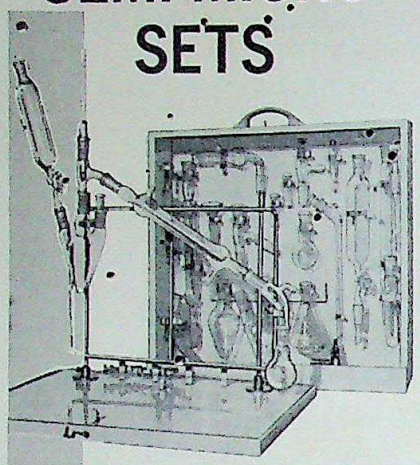

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phthalocyanine literature the quotations correspond to extensive patent reading. A few typographical errors were noted, but these were not serious enough to cause difficulty.

HENRY J. KEHE
B. F. Goodrich Research Center
Brecksville, Ohio

Farben in Kultur und Leben

Hans Kramer and *Otto Matschoss.* Ernst Battenberg Verlag, Stuttgart, 1963. 276 pp. Figures. 25 × 35 cm. 138 DM ($33.50).

In August, 1863, Friedrich Bayer began the manufacture of aniline at Barmen. This modest undertaking has now grown into the colossus known as Farbenfabriken Bayer AG, which in 1962 offered 8500 items of which 3500 were dyes and related products. The centenary of this corporation will be appropriately celebrated and the volume under review here was issued in honor of this occasion. It fittingly bears the title "Colors in Culture and Life," and presents an encyclopedic treatment of this vast subject. The level of the discussions is nontechnical but adult; the aim has been to entertain and inform the educated general public.

The text has been divided into four main topics, each with competent authors. The first three divisions are entitled: Nature and Color; The Magic of Color; Man and Color, which in turn are divided into sections each with a separate heading. In this way practically the entire field has been covered in various degrees of extension and depth. Typical topics are: the physics of color, the perception of color, the colors used at various periods of human history, the cave paintings, color in the animal, vegetable, and mineral kingdoms, the psychological aspects of color, the theory of colors and their combination, mosaics, cermics, glasses, tapestries, the history of painting, the symbolism of color, etc. In short, there are few facets of the subject that have not been at least mentioned.

Chemists will be particularly interested in the fourth main division: Coloring Matters Through the Centuries. The author is Rudolf Sachtleben, formerly curator of the chemical section of the Deutsches Museum in Munich and an experienced essayist in the field of the history of materials. He here has given an expert account of colors since the glacial periods, stressing the mineral, animal and vegetable materials used by artists and dyers through these many centuries. There are no equations or structural formulas but the essential information is nevertheless all there. This portion of the book in itself will commend the volume to teachers and students.

The excellence of the text is fully matched by the beauty and appropriateness of the 99 illustrations. They are all in

(*Continued on page A980*)

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Some Cosmochemical Problems: Notes on the Thirty-Seventh Annual Priestley Lectures

Harold C. Urey, University of California, San Diego. Pennsylvania State University, University Park, 1963. x + 181 pp. Figs. and tables. 21.5 × 27.5 cm. Paperbound. $3.25.

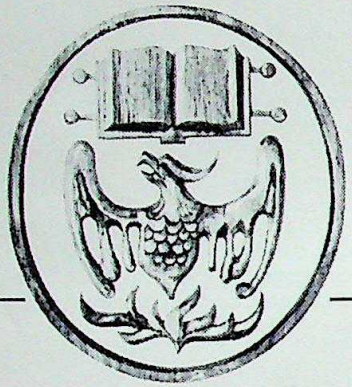
This paperbound book consists of notes prepared from tape recordings and slides used by Professor Urey in the presentation of the Thirty-Seventh Annual Priestley Lecture Series at Pennsylvania State University. The notes, as compiled by an editorial committee, were submitted to Professor Urey for his comments and corrections.

The volume consists of notes from five lectures entitled: Chapter I, The Moon; Chapter II, The Abundance of the Elements; Chapter III, The Origin of the Solar System-I; Chapter IV, The Origin of the Solar System-II; and Chapter V, The Origin of the Elements. Questions from the audience and Dr. Urey's answers are included. As stated by Dr. Urey, most of the material covered in the lectures has been published in review articles he has written in "Space Science," John Wiley and Sons, 1963 and "The Moon," Academic Press, 1962. The principle merit of this volume of lecture notes is that it is addressed to non-specialists in cosmochemistry. Dr. Urey takes care to trace the historical evolution of the ideas and theories he discusses. This unfolding process leads to a far greater appreciation by the reader of the serious problems in this field, than if only current theories were discussed.

As might be expected in a book derived from transcriptions of lecture notes, there are some weaknesses. Proofreading of the manuscript was poorly done and typographical errors are common. Spelling of names in the references was quite variable with, for example, Suess and Seuss being used about equally. The material is not as well organized as it would be in a manuscript specially written for publication. For example, terms such as "chondrites" are used in the text many pages before they are finally defined. In several cases extensive tables of data are presented, whereas the text will only briefly touch on their significance. References to original sources of the data presented are quite deficient.

In summary, the editorial committee has succeeded in capturing the inimitable style of Dr. Urey speaking about a field to which he has made significant contributions and in which he is vitally interested. The book can be read by the non-specialist profitably and with enjoyment. While certainly not a text or a source book for the specialist, the book could be used effectively by college teachers and advanced students in chemistry, and other physical sciences for supplemental reading in a new and fascinating field of chemistry. Its modest cost should allow its inclusion into even the smallest libraries.

WILLIAM D. EHMANN
University of Kentucky
Lexington



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348 pages, 18 plates, line illus., index $12.50

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Modern Chemical Engineering. Volume 1, Physical Operations

Edited by *Andreas Acrivos*, Stanford University, Stanford, California. Reinhold Publishing Corp., New York, 1963. ix + 604 pp. Figs. and tables. 16 × 23.5 cm. $19.50.

The stated primary objective of this book (and future series of volumes) is to condense a major portion of the increasing volume of literature in a special field and to bring it into perspective in a convenient form. The book is edited by Professor Acrivos and each of the eleven chapters is prepared by blue-ribbon authorities in

(*Continued on page A983*)

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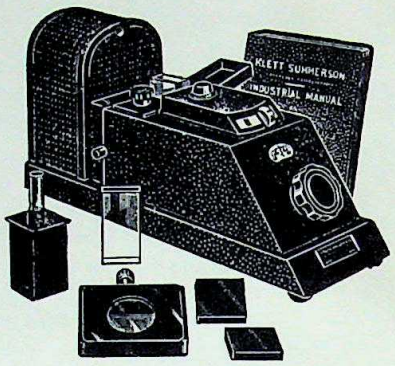

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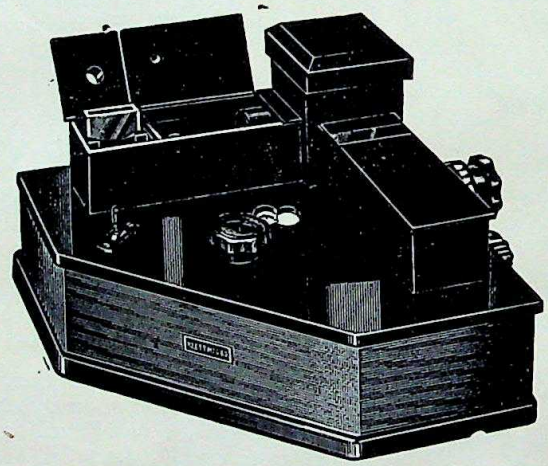

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their respective fields. In each chapter the author presents the past accomplishments, current methods, and future trends in the subject under discussion. These men have done an excellent job capsuling the literature in these special areas for the reader.

The contents are as follows: Laminar Flow of Single-Phase Newtonian Systems by Professor Acrivos; Turbulent Flow of Newtonian Systems by C. A. Sleicher; Liquid-Liquid Extraction by R. B. Olney and R. S. Miller; Non-Newtonianism in Thin Liquids: Molecular and Physical Aspects by E. W. Merrill; Viscoelastic Phenomena in Thick Liquids: Phenomenological Analysis by A. G. Frederickson; Solid-Fluid Systems by F. A. Zenz; Flow of Fluids Through Porous Materials by R. E. Collins; Gas-Liquid Flow in Conduits by A. E. Dukler and M. Wicks, III; Absorption and Distillation by J. E. Vivian and C. J. King; Chromatographic Separations by R. F. Baddour and J. R. Valbert; Process Dynamics and Control by L. Lapidus and D. E. Lamb.

The only critical comment from this reviewer is the type used in the printing of the book. Apparently, the type is too bold and after several hours of perusal, the efficiency of reading decreases greatly as compared to the type used in most chemical engineering books. In many cases the figures are difficult to read because of the small size. These are minor items but should be taken care of in the following editions.

A copy of this book should be on the book shelf of each professor and each industrial worker specializing in one of the areas covered by the book.

JOHN J. MCKETTA
University of Texas
Austin

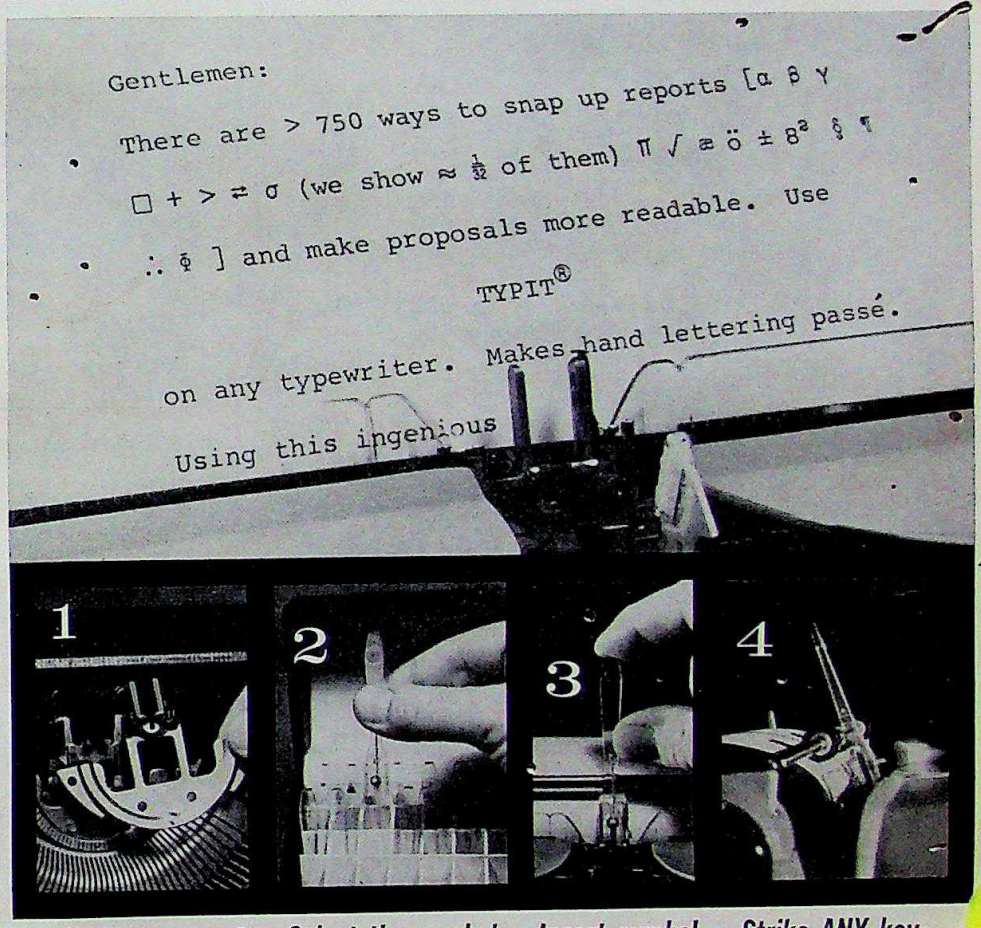
The Organic Constituents of Higher Plants: Their Chemistry and Interrelationships

Trevor Robinson, University of Massachusetts, Amherst. Burgess Publishing Co., Minneapolis, Minn., 1963. iii + 306 pp. Figs. and tables. 22 × 28.5cm. $6.75.

As biological research has become more and more a matter of chemical investigation, the need of the biologist for knowledge on the chemistry of natural products from a biological rather than chemical outlook has become more urgent. The purpose of Professor Trevor Robinson's book is to provide botanists with a survey of the types of organic compounds that occur in higher plants and their interrelationships without the burden of information of interest only to the chemist. Although the brief chapter titles do not indicate it, the compounds are grouped according to their mode of biogenesis rather than strictly by chemical structure; this novel and useful classification is an outstanding characteristic of the book. For each group are given the structures and sources of representative and unusual examples, chemical and physical properties, and function, techniques of isolation and characterization, and literature references to comprehensive reviews and specific papers. The danger of mistaking artifacts produced during isolation for naturally occurring compounds is well illustrated. For well-known classes such as carbohydrates and amino acids, emphasis is placed on lesser known examples, but for alkaloids, the importance and widespread occurrence are not adequately conveyed. Structure proofs and syntheses, which usually occupy much of the literature on natural products, are not discussed, since they are not of concern to the biologist. In almost all instances it will be necessary to consult the original literature or reviews for the details on experimental procedures or for inclusive lists of compounds of a given group; the well-selected references make this no problem at all.

The survey of structures produced by higher plants is quite extensive; the only omissions noted by this reviewer are the fluorine-containing fatty acids present as toxic constituents of several plants and 2-aminoethylphosphonic acid, the only known occurrence of the C—P bond. Readers desiring to acquire a knowledge of the types of compounds that occur naturally should bear in mind that this is not a survey of all natural products found in plants and that a very large part of the recent work in the field has been concerned with microorganisms, from which much more unusual types of structures have been obtained. (The latter are cataloged in "The Pfizer Handbook of Microbial Metabolites.")

(*Continued on page A985*)



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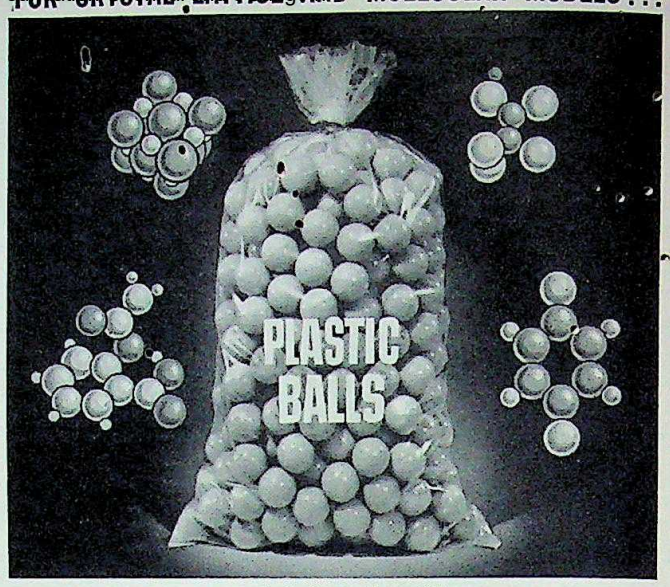

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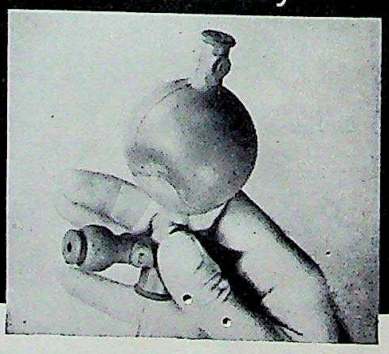

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The very few typographical errors in the text are trivial. A book of this type requires a large number of structural formulas, and the abundance of such formulas is another excellent feature. Although most of the formulas have been reproduced directly from the author's drawings, there are numerous errors, perhaps more than average for such books. A large number of the formulas were checked; errors were noted in the structures given for salicin, gentisic acid, collinin, tasmanone, α-kosin, khellin, eucarvone, lanceol, hecogenin, solanidine, fukugetin, thiamine, folic acid, and folinic acid. Although such errors seriously detract from an otherwise well-executed book and will be a thorn to workers, they should not bother the general reader. The avoidance of unnecessary chemical jargon and conventions is desirable in a book intended primarily for biologists, but the use of double-headed arrows for reversible reactions (pp. 31, 32) is objectionable to chemists; the nonconventional representation of porphyrin rings is confusing; and the expression, "methylation increases the redness," (p. 186)—bathochromic shift or hyperchromic effect?—is ambiguous.

This book can be highly recommended not only to botanists but to chemists and all workers in the field of natural products. Teachers of organic chemistry would profit by browsing through this book to become aware of the pattern of carbon compounds in nature, and the book should be placed near the top of the bibliography for courses in the chemistry of natural products.

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New Volumes in Continuing Series

The following titles are those of volumes in continuing series. Many of these series are familar to readers, who are best served by prompt announcement of the appearance of new titles. The policy of THIS JOURNAL will be to publish full reviews only of inaugural volumes in new series. The publication of later volumes will be announced in this column. Full bibliographic information will be supplied as well as a list of contributing authors.

Comprehensive Biochemistry. Volume 7, Proteins, Part 1

Edited by *Marcel Florkin*, University of Liége, Belgium, and *Elmer H. Stotz*, University of Rochester, Rochester, New York. American Elsevier Publishing Co., New York, 1963. xii + 280 pp. Figs. and tables. 15.5 × 23 cm. $13.50.

Contributors: E. Gordon Young; H. Fraenkel-Conrat; R. Trautman; H. A. Scheraga; R. L. Baldwin; K. O. Pedersen; D. W. Green.

Comparative Biochemistry: A Comprehensive Treatise. Volume 5, Constituents of Life, Part C

Edited by *Marcel Florkin*, University of Liége, Belgium, and *Howard S. Mason*, University of Oregon Medical School, Portland. Academic Press, Inc., New York, 1963. xix + 637 pp. Figs and tables. 16 × 23.5 cm. $20.

Contributors: B. Tschiersch and K. Mothes; Hajime Takahashi, Shigehiko Taniguchi, and Fujio Egami; C. Lioret and A. Moyse; Jerome Gross; E. C. Wassink; Jean Roche, Maurice Fontaine, and Jacques Leloup.

Advances in Enzymology. Volume 25

Edited by *F. F. Nord*, Fordham University, New York. Interscience Publishers (a division of John Wiley and Sons, Inc.), New York, 1963. v + 565 pp. Figs. and tables. 16 × 23.5 cm. $15.

Contributors: Manfred Eigen and Gordon G. Hammes; J. A. Bassham; W. D. McElroy and H. H. Seliger; Charles Walter and Earl Frieden; Youssef Hatefi; Theodor Wieland and Gerhard Pfleiderer; Jakob A. Stekol; David M. Greenberg; Roger W. Jeanloz; W. G. C. Forsyth and V. C. Quesnel.

Treatise on Analytical Chemistry. Part 2, Analytical Chemistry of the Elements, Volume 8

Edited by *I. M. Kolthoff*, University of Minnesota, Minneapolis, and *Philip J. Elving*, University of Michigan, Ann Arbor, with the assistance of *Ernest B. Sandell*, University of Minnesota. Interscience Publishers (a division of John Wiley and Sons, Inc.), New York, 1963. xxi + 556 pp. Figs. and tables. 17 × 24 cm. $20.00.

Contributors: Mark M. Woyski and Ray E. Harris; James S. Fritz; H. R. Grady; Winslow H. Hartford; Thomas J. Walsh and Eugene A. Hausman.

Advances in Mass Spectrometry. Volume 2

Edited by *R. M. Elliott*, Associated Electrical Industries, Ltd., Manchester, England. Pergamon Press (The Macmillan Co.), New York, 1963. xvii + 628 pp. Figs. and tables. 16.5 × 23.5 cm. $20.

Sections: Session A, Mass Spectrometry in Research, A. O. Nier, chairman; Session B, Mass Spectrometry of Inorganic Compounds, J. D. Waldron, chairman; Session C, New Instruments and Techniques, J. Mattauch, chairman; Session D, Mass Spectrometry of Organic Compounds, Part 1, Theory and Correlation of Mass Spectra, C. La Lau, chairman; Session E, Mass Spectrometry of Organic Compounds, Part 2, Mass Spectra and Analysis, R. R. Gordon, chairman; Session F, Ionization and Dissociation, V. H. Dibeler, chairman.

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CHEMICAL PROJECTS

Research Ideas for Young Chemists

Compiled by
JAY A. YOUNG, King's College, Wilkes-Barre, Penna.
JOHN K. TAYLOR, National Bureau of Standards, Washington, D. C.

Determination of Saponification Equivalents of Phenolic Esters

See TOBEY, S. W., *et al.*, *J. Chem. Educ.*, 38, 611 (1961).

In the identification of compounds many different properties can be used such as molecular weight, color, infrared absorption characteristics, behavior in various chemical environments, and others. One identifying feature, often used for esters, is the weight (in grams) of ester per equivalent of base needed to saponify the ester. This ratio is called the "saponification equivalent." Phenolic esters often do not yield reproducible saponification equivalents when the procedures described in various reference works are used. The authors have developed a procedure which does give reliable results with phenolic or any other esters.

Questions:

The authors state that they are not sure why the older procedures for the determination of the saponification equivalent of an ester often fail with phenolic esters, though they do suggest a few possible reasons. Can you establish that one or more of the reasons they suggest are valid, or, can your determine some other explanation?

The authors indicate that phenolphthalein cannot be used as an indicator in the back titration step of their procedure since phenol is itself acidic enough to react appreciably with the base before the phenolphthalein has changed color. Therefore, they recommend the use of another indicator. Phenolphthalein could be used, however, if before the back titration the phenol were tied up chemically in some way so that its acidic character would not be evident. Can you suggest a practical scheme for accomplishing this result?

When determining the saponification equivalent of phenolic esters which have a nitro substituent on the aromatic nucleus, thymolphthalein should be used as the indicator in the back titration step because most substituted phenols have *p*K values less than 9.2. Can you find any phenolic esters with a nitro substituent on the aromatic nucleus for which thymophthalein is not required as the indicator in the back titration step? Or, can you find any other aromatic esters, in addition to those mentioned by the authors, which are not nitro derivatives of phenol, for which thymolphthalein is required as an indicator in the back titration step?

Can you succeed where the authors failed, and develop a mixed indicator which would be suitable for both types of phenolic esters, those with phenol derivative moieties with *p*K values above, and below, 9.2?

The saponification equivalents of carboxylic acid esters of polyhydroxyl aromatic compounds and of esters of *p*-hydroxybenzoic acid and *p*-hydroxycinnamic acid cannot be determined by the procedures described. Can you devise a suitable procedure for one or more of these classes of esters?

NOTES: The investigations suggested by the questions here are recommended for the student who has a strong interest in, and comprehension of, organic chemistry and analytical chemistry.

The use of tris(hydroxymethyl)aminomethane as a primary standard, though recommended, is not mandatory. See THIS JOURNAL, 36, 297 (1959). Similarly, apparatus with standard taper joints will facilitate the experimental work but is not essential.

A Biochemistry Laboratory Experiment

See SCHER, I., *et al.*, *J. Chem. Educ.*, 38, 632 (1961).

When an electrical discharge is passed through a gas or mixtures of gases, new products are often formed as a result of the action of the electrical discharge. It has been postulated that prior to the existence of life on the earth, an analogous natural process produced the essential components for living forms, which then followed as a consequence. The authors of this article report that they found evidence for the formation of some amino acids and other products when an electrical discharge was passed for several days through a mixture of ammonia, water vapor, and ordinary burner gas.

Question:

Construct an apparatus similar to that described in the article and fill it with a suitable gas or gas mixture. Pass an electrical discharge (a spark coil from a "Model T" Ford—these are still available at reasonable cost—can be used instead of the induction coil recommended) through the gas for a suitable period of time, and identify as many of the products formed as possible. Account for the formation of these products and test your suggestions by further laboratory work.

NOTE: Since explosive mixtures of gas may inadvertently be used initially or might be formed during the course of a run, be sure to use safety shields and to wear safety goggles when conducting this investigation.

A Constant Current Source for Student Use

See MANN, C. K., AND CHAMPEAUX, V. C., *J. Chem. Educ.*, 38, 519 (1961).

For many modern studies in quantitative analytical chemistry a source of constant current is necessary. Most of these studies comprise investigations in one of these fields: coulometric titration at constant current, potentiometric titration at constant current, chronopotentiometry, and current scanning potentiometry. Of these the first is probably the simplest for a beginner to study.

In the article, the construction of an inexpensive transistorized constant current source is described. No specific suggestions are made for its use in an experimental investigation.

Question:

Construct the constant current source described and use it to help solve a problem posed in another chemical project in this series. It is suggested that the first problem you select involve a titration which you can adapt to a constant current coulometric titration.

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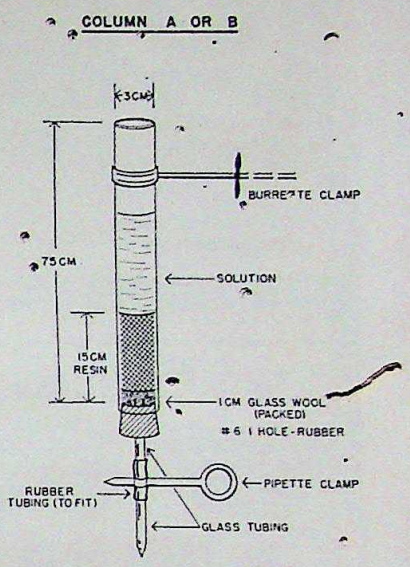
REMOVAL OF HARDNESS AND DEIONIZATION OF WATER BY THE ION EXCHANGE METHOD

A Chem Ed TESTED DEMONSTRATION

Submitted by: A. W. Sangster, University College of the West Indies, Jamaica
Checked by: Marcus Kraus and James Ramer, Tenth Chemistry Institute, Montana State College

Materials: Cation Exch. Resin, Amberlite IR-120 (Col. A); Anion Exch, Resin, Amberlite IRA-400 (Col. B); hard water, 1 liter of 2% $CaCl_2$ soln; 500 ml of 10% NaCl soln; 250 ml of 1 *M* HCl; 250 ml of 1 *M* NaOH; 0.5 *M* $(NH_4)_2C_2O_4$ soln for Ca^{++} test; 0.25 *M* $AgNO_3$ soln for Cl^- test.



PART I—Removal of Hardness (Ca^{++})

Preparation of column A: Pass through 250 ml NaCl soln slowly until effluent positive for Na^+ with Nichrome wire. Wash column thoroughly with 500 ml distilled water.

Test: Add 4 drops methyl orange to 250 ml hard water. Pass through column. Test pink effluent for absence of Ca^{++}. Demonstrate removal of Ca^{++} from column A by passing through 200 ml NaCl soln. Test for Ca^{++}.

PART II—Deionization (Ca^{++} and Cl^-)

Preparation Column A	*Preparation Column B*
Pass through HCl soln until negative for Na^+. Test with Nichrome wire. Wash until effluent negative for Cl^-.	Pass through NaOH soln until positive for alkali (litmus). Wash with 500 ml distilled water.

Test: Add 5 drops methyl orange to 300 ml $CaCl_2$ soln. Pass through column A. Then pass pink effluent through column B. Test for absence of Ca^{++} and Cl^-.

Note: Respective column must be thoroughly washed with HCl and NaOH before test.

PART III

Removal of Ca^{++}:
(cation exchange): $2[RSO_3^-Na^+] + Ca^{++} \rightleftharpoons [(RSO_3^-)_2Ca^{++}] + 2Na^+$

Deionization:
(cation exchange): $2[RSO_3^-H^+] + Ca^{++} + 2Cl^- \rightleftharpoons [(RSO_3^-)_2\,Ca^{++}] + 2H^+ + 2Cl^-$

(anion exchange): $[R'N(CH_3)_3OH^-] + H^+Cl^- \rightleftharpoons [R'\overset{+}{N}(CH_3)_3Cl^-] + H_2O$

VAPOR SHADOWGRAPHS

A Chem Ed TESTED DEMONSTRATION

Submitted by: L. Carroll King and A. D. Templer, Northwestern University, Evanston, Illinois

Checked by: John Shotwell, Detroit Public Schools, Michigan

PREPARATION

Provide an ultraviolet light, a fluorescent screen, a beaker or shallow dish containing the test liquid, and a long glass tube.

DEMONSTRATION

The fluorescent screen is placed in the ultraviolet light beam and the beaker of test liquid is placed near the screen. With the long glass tube blow across the liquid surface. The shadow of the vapor may be observed on the fluorescent screen.

REMARKS

Pyridine, benzene, and mercury absorb strongly in the ultraviolet; their vapor shadows are easily observed. The vapor shadows of acetone, mesityl oxide, anethol, and anisaldehyde can be seen but not so easily as the first three mentioned.

The ultraviolet light source should produce the shorter wavelengths and should be equipped with a filter to remove as much of the visible light as possible.

Note on Fluorescent Screens

A laundered white shirt makes a fine fluorescent screen. White paper used for letterheads is usually satisfactory. Crystalline anthracene or uranyl acetate spread evenly over a cardboard which is covered with a thin layer of glue will work very well.

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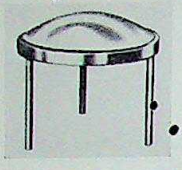

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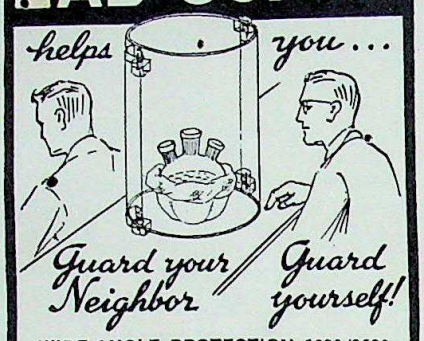

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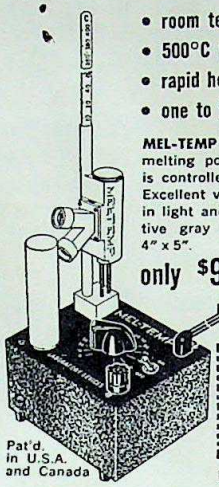

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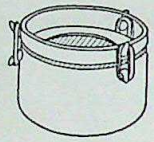

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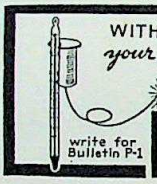

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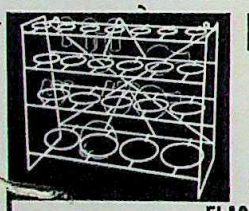

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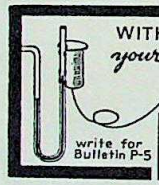

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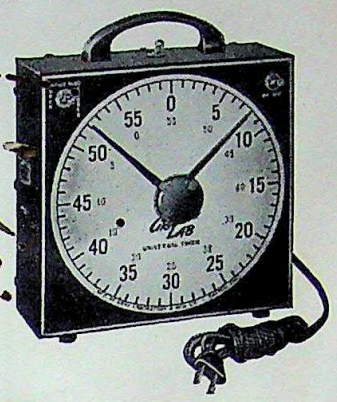

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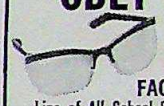

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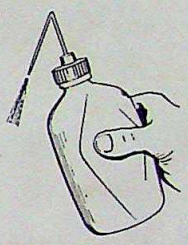

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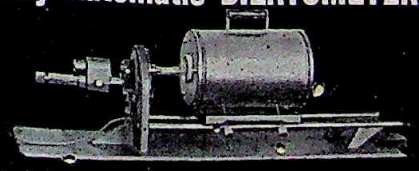

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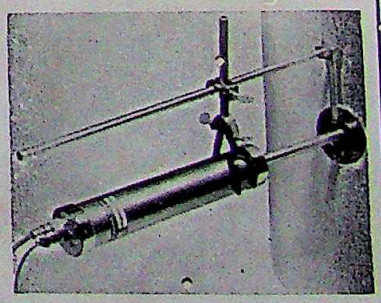

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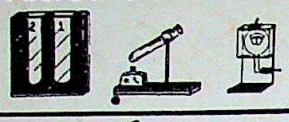

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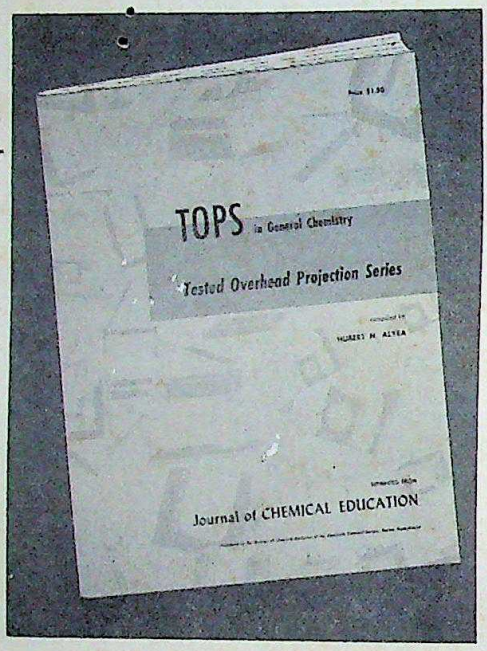

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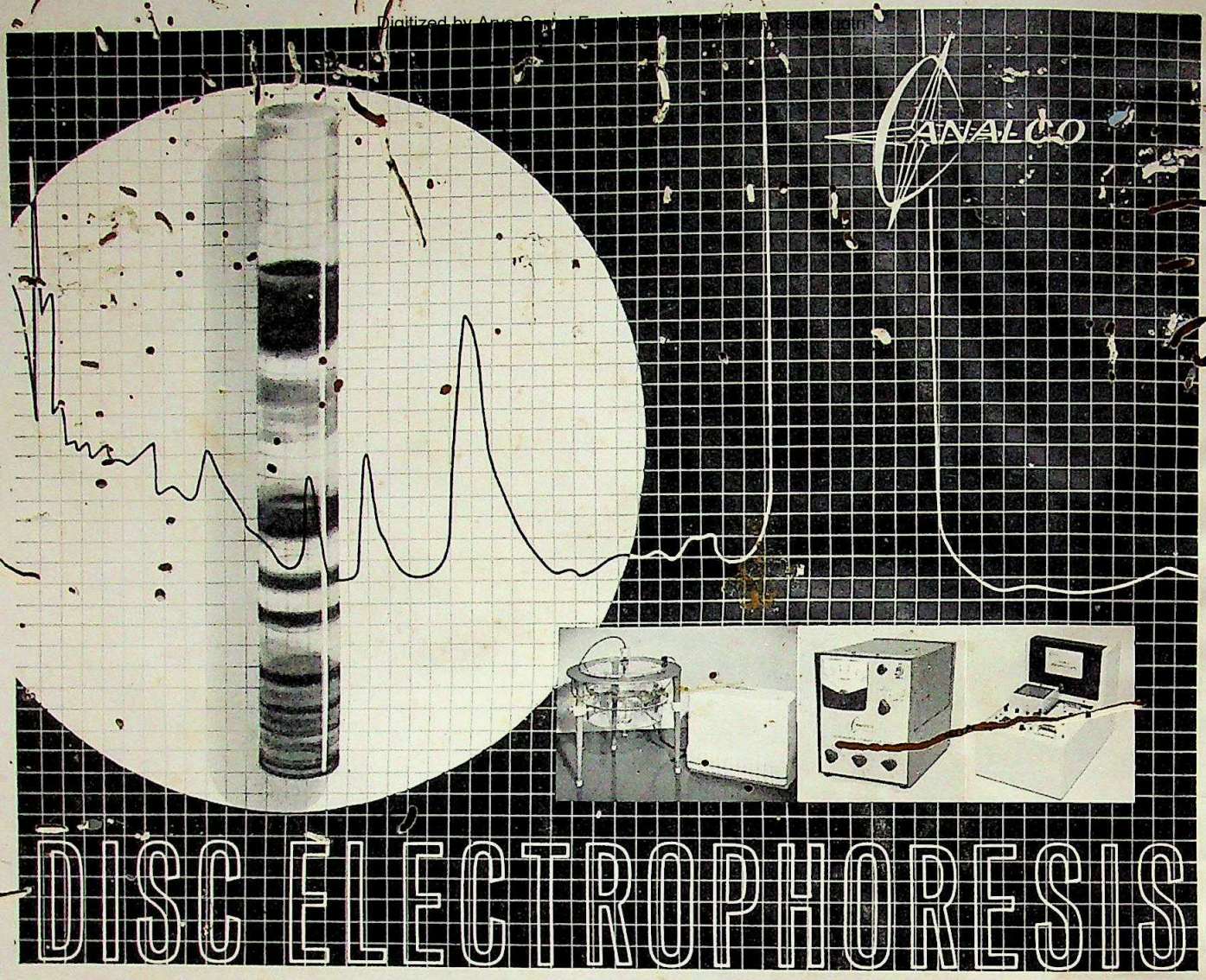

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